REPORT ON THE WATER-POWER

OF THE

OHIO RIVER BASIN

AND

OHIO STATE CANALS.

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BOSTON, MASS., *July* 16, 1883.

Professor W. P. TROWBRIDGE.

SIR: I have the honor to submit a report upon the water-power of so much of the Ohio River basin as could be examined during the limited period available before the stoppage of field-work. The investigations that were made were conducted during the winter of 1882–'83, and covered, it is thought, those streams having the greatest present importance with respect to water-power. It is desired to call attention to the principles observed in the estimates of flow and power, which are fully explained in connection with the report on the region tributary to Long Island Sound.

Very respectfully,

DWIGHT PORTER.

THE OHIO RIVER BASIN.(a)

SURFACE FEATURES, AND DESCRIPTION OF THE MAIN RIVER.

By the union of the Allegheny and Monongahela rivers at Pittsburgh the Ohio river is formed, with a drainage basin at that point of between 18,000 and 19,000 square miles, which, after a course of nearly a thousand miles to the southwest, is increased to about 214,000 square miles at the junction with the Mississippi. The principal streams which contribute to this increase are, on the north side, the Beaver, Muskingum, Scioto, Great Miami, and Wabash rivers, and on the south side, the Little Kanawha, Great Kanawha, Big Sandy, Licking, Kentucky, Green, Cumberland, and Tennessee. The head-waters of the Allegheny are in northern Pennsylvania and southwestern New York; those of the Monongahela, nearly 250 miles distant, in West Virginia. The eastern watershed line of the Ohio, therefore, cuts entirely across the state of Pennsylvania, at a distance from the western border ranging from 80 miles in the south to about 130 miles in the north. Passing out of this state, the northern boundary of the river basin runs through New York, Ohio, and Indiana, being carried in the latter state around the upper waters of the Wabash nearly to the Michigan line, and considerably more than 200 miles north of the main river itself; it then enters Illinois and strikes southerly through that state to the mouth of the Ohio at Cairo. The southern boundary runs from Pennsylvania across a corner of Maryland, embraces nearly all of West Virginia, forming in part the dividing-line between that state and Virginia; it crosses the southwestern portion of the latter state and the western part of North Carolina, and by the Tennessee basin is extended down into Georgia and Alabama, reaching there a distance of 300 miles south of the Ohio; it continues from Alabama across the adjacent northeastern corner of Mississippi, and finally traverses the extreme western portions of Tennessee and Kentucky.

The vast extent of country included within the limits described possesses great variety of surface features, and these affect correspondingly the character of the streams draining the different sections. For 700 or 800 miles the general course of the eastern and southern boundary of the drainage basin of the Ohio lies along the crests of the Alleghany Mountain ranges, peaks of which attain in North Carolina elevations of 6,000 feet and over. Down the western slopes of these mountains there flow streams to join the Allegheny, Monongahela, Kanawha, and Tennessee rivers, running through a country often of the wildest description, but magnificently timbered, and rich in deposits of coal, iron, building-stone, copper, gold, and other minerals. Among these mountains many of the streams have a very rapid fall, and are subject to large and frequently sudden fluctuations in volume, rendering them in consequence unreliable for power. The country being sparsely settled, they are utilized to but a comparatively small extent, and that mainly by saw- and grist-mills. Advancing to the west and northwest from this mountainous district we find it succeeded by a beautiful undulating country, fertile, well settled, and cultivated. To the north of the Ohio river, in the states of Ohio and Indiana, the surface continues for some distance quite broken, and then subsides into gently-rolling land, once heavily wooded, but now cleared, and very productive. After leaving the mountains the streams heading in them gradually increase in volume by accessions from tributaries, and at the same time lose in rapidity of descent, until in their lower courses most of the larger affluents of the Ohio have but a small slope, and are either navigable or capable of being made so without much difficulty. To illustrate the changed character which some of the streams assume, it may be mentioned that the Cheat river, flowing through the mountains of West Virginia, falls 2,400 feet in the last 80 miles of its course, while the Monongahela, into

a Owing to the stoppage of field operations in January, 1883, the examination of rivers in this region was confined to those above and including the Great Miami on the north side of the Ohio, and to the Monongahela and Little Kanawha on the south side.

which it empties a little west of the Laurel Hill range, descends but 75 feet in the 90 miles from the mouth of the Cheat to Pittsburgh. Brief data regarding some of the principal rivers flowing into the Ohio, in part taken from Humphreys and Abbot's report, are given below:

Name of river.	Drainage area.	Remarks.
	Sq. miles.	
Allegheny river at Franklin	5,007	Entire length, about 325 miles. Navigable about half the year for small steamers to Franklin, 123 miles above Pittsburgh. Fall from Olean, New York, to Franklin, Pennsylvania (132 miles), 446 feet; thence to Pittsburgh, 270 feet, or 2.27 feet per mile. Country drained, in general mountainous and rough, with heavy growth of timber. Above Corydon, 209 miles from the mouth, power is used at intervals on the main river for saw-mills.
Allegheny river at mouth	11,107	
Monongahela river at Morgantown	2,737	Basin in part mountainous and timbered, and in part rolling country cleared and cultivated. Fall from mouth of West fork to Pittsburgh (say 123 miles), 132 feet, or an average of 1.07 foot per mile. The present system of locks and dams is being extended to give navigation to Morgantown, 102 miles from the mouth. Thence to Fairmount, 20 miles or so above, the stream is utilized for power by several small grist-mills.
Monongahela river at mouth	7,025	
Beaver river	3,030	Falls about 130 feet from New Castle to the mouth. Not navigable, but utilized within a few miles of the mouth for power by a considerable number and variety of manufacturing concerns.
Little Kanawha river	2,290	Fall from Bulltown to mouth, 199½ feet in 193¾ miles, or an average of about 1⅛ foot per mile. Four-foot slack-water navigation is maintained to Burning Springs, 40 miles from the mouth, and is being extended somewhat above by the national government. A small grist-mill utilizes power at one of the dams. The flow of the stream is unreliable, and is subject to great and remarkably sudden fluctuations. Lumbering is the chief industry on the river.
Great Kanawha river	.....	Fall in 80 miles above mouth is given by Humphreys and Abbot as 86 feet, or an average of about 1 foot per mile. By a system of locks and dams, part of the latter fixed and part movable, the national government is engaged in improving the navigation of the river, with the aim of insuring a continuous depth of 7 feet from the mouth to the upper river, naturally tributary to which are magnificent coal-fields.
Muskingum river	7,740	Navigation by means of locks and dams maintained to Dresden, 91 miles from the mouth, by the state of Ohio. Fall in same distance 130 feet, an average of 1.4 foot per mile. Power utilized to a moderate extent at a number of the dams.
Scioto river	6,400	Not navigable, and not utilized for power below Columbus. Drains a farming region. Fall from Columbus to the mouth, 225 feet in 110 miles, or an average of about 2 feet per mile. Greatest elevation in drainage basin between 1,500 and 1,600 feet above sea-level.
Great Miami river	5,400	Fall from Dayton to the mouth, 298 feet in 77 miles, or 3.9 feet per mile on the average. River not navigable, but has been improved for power at numerous points, and sustains important manufacturing interests, the most prominent industry along its course being the manufacture of paper.
Big Sandy river	3,950	The main river is navigable, and this, together with the principal forks, Louisa and Tug, is being improved by the United States government for navigation by the removal of rocks, fallen trees, and other obstructions. Steps have also been taken to inaugurate a system of slack-water navigation, and a site for a dam has been fixed upon near the junction of the forks.
Licking river	3,870	Fall from West Liberty, Morgan county, to the mouth, 310 feet in 231 miles, an average of 1.34 feet per mile. Flow very variable. Navigation is carried on to a small extent. Surveys have been made and are still in progress (1881) to determine the practicability of establishing slack-water navigation.
Kentucky river	7,870	Falls 228 feet in the 258 miles from the mouth of the Middle fork to the mouth of the main river, an average of about 0.9 foot per mile. Lower 95 miles of river improved many years ago for navigation, by state of Kentucky, by means of locks and dams. These are now being repaired by the national government.
Green river	.....	Average slope for 175 miles above the mouth given by Humphreys and Abbot as 4½ inches per mile. Slack-water navigation is maintained from the mouth to Bowling Green, through the distance above mentioned, by means of five locks and dams, originally built by the state of Kentucky, but now operated by the Green & Barren River Navigation Company.
Wabash river	.....	Fall given by Humphreys and Abbot as 57 feet in the 91 miles from the mouth of White river to the Ohio; and as 385 feet in the 370 miles below the mouth of Little river, giving an average descent for the entire distance of 0.96 foot per mile, and below White river 0.63 foot per mile. The lower river is regularly navigable, and improvements and surveys are in progress under the national government, with the view of extending low-water navigation up the river.
Cumberland river	.....	Rises in the Cumberland mountains and descends rapidly to the plains, after which it flows more gently to the falls. It is then inclosed between high bluffs, and has a rapid current as far down as Laurel river. Here begins the coal region, which extends 13 miles down the stream. The principal obstructions to navigation below are Smith's shoals, 358 miles above Nashville, where there is a total descent of 55 feet in 8 miles on four shoals. From Nashville to the mouth, 192 miles, the average fall is 0.41 foot per mile. Between the mouth and Nashville the river is navigated during six months in the year by steamers of from 300 to 500 tons and less. For nine or ten months in the year it is navigable over the same distance for boats of 20 inches draught. Above Nashville navigation extends, for from four to six months in the year, for steamers of 3 feet draught, 358 miles to Point Burnside, crossing-point of the Cincinnati Southern railroad. The Falls of the Cumberland have been surveyed and reported on under date of February, 1879, by Mr. Samuel Whinery, United States assistant engineer (see *Report of Chief of Engineers*, 1879). As described by Mr. Whinery, "The great falls of the Cumberland river are situated in the southwestern part of Whitley county, Kentucky, about 60 miles by river above Point Burnside, and 12 miles east of the line of the Cincinnati Southern railroad. The river at and above the falls is a rapidly-descending mountain stream carrying a large volume of water at flood tide, and shrinking to a mere brook during extremely dry seasons. Geologically, the fall is situated in the 'millstone grit' or 'cliff rock' of the Upper Coal Measures, through which it has cut a deep and narrow chasm, with walls often 300 feet high and almost perpendicular." The survey extended from a point 1 mile above, to a point about 1¾ mile below, the great fall, covering a descent of 84.5 feet in the river, of which 51.1 feet was assigned to the great fall.
Tennessee river	.....	The Holston river, the true source, rises in the Alleghany mountains, 2,500 feet above sea-level. It is a rapid stream, running over a rocky bed and through a narrow valley. It is joined successively by the French Broad and Clinch rivers. Islands are numerous. The river is contracted in several places by high promontories and is made deep and rapid. The course is then more direct, and the current is gentle to Muscle shoals, which for about 23 miles, between Florence and Decatur, Alabama, obstruct navigation. The total fall in 36.5 miles, including these shoals, is given by Humphreys and Abbot as 134 feet. Except at Muscle shoals, there is continuous navigation from Chattanooga to the mouth of the river, 453 miles. The improvement of navigation at the shoals, and also at points above Chattanooga, is being prosecuted by the national government.

There can be no question that, in their upper courses, above the limits of navigation, the various tributaries on the south side of the Ohio, and their own affluents, present in the aggregate much available water-power, but no opportunity was afforded to examine personally any of those below the Monongahela. Those to the north of the Ohio are already largely in use, and will admit of much further development. The powers offered by the latter, though well suited to the demands of ordinary manufacturing, are not, individually, of great magnitude, for the reason that the fall at command on the principal streams is nowhere very large, while their volume of flow is on a rather small

scale relatively to the extent of area drained, and in the dry season sinks in many cases very low; so that, if their value is to be estimated on the basis of permanently reliable power, they can not take a high rank. There are probably no privileges on the northern tributaries of the Ohio which can be depended upon at all times for more than 1,000 or 1,500 effective horse-power, and even such are of unusual occurrence.

The proportion of the rainfall which is discharged by the streams is, generally speaking, considerably less in the Ohio River basin than in New England and New York, but too little is known to admit of much certainty either in statement or in estimate regarding the real numerical ratio. Humphreys and Abbot estimated the average annual rainfall of the entire basin to be about 41½ inches, and 24 per cent. of this to be carried off by the river. The climate, the deep soil, the permeable underlying strata, and the open character of much of the country drained, denuded of its timber, doubtless all have an influence in producing a low percentage. The streams also suffer from being deficient in that natural regulation of flow afforded in some sections of the United States by an abundance of springs, lakes, and swamps. The rainfall and temperature must, of course, vary widely over so extended a region as we are considering. The following table does not exhibit the extremes, nevertheless it gives the results of observations of these phenomena at a number of prominent points, and will convey a fair idea of their range over different portions of the river basin:

Records of rainfall and temperature at points in the Ohio River basin. (a)

Locality.	RAINFALL.							TEMPERATURE.					
	Altitude above ocean-level.	Number of years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.	Number of years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.
	Feet.		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*
Jamestown, New York (in upper Allegheny basin)	1,454	8	9.86	12.10	11.23	9.91	43.16	3	44.41	66.07	48.65	24.69	46.18
Pittsburgh, Pennsylvania	840	16	8.86	10.72	8.21	7.01	35.40	12	49.68	72.41	54.03	31.64	51.94
Kanawha, West Virginia (in Great Kanawha basin)	.....	.....	.....	.....	.....	.....	.....	8	54.38	71.40	54.65	30.06	54.27
White Sulphur Springs, West Virginia (in Great Kanawha basin).	2,000	5	10.07	10.63	7.30	9.51	37.54	.....	.....	.....	.....	.....	.....
Wytheville, Virginia (in upper basin of Great Kanawha)	2,287	9	10.38	11.07	8.46	9.23	40.04	4	51.35	70.33	51.82	34.03	52.11
Asheville, North Carolina (in upper basin of Tennessee river)	2,250	6	10.33	13.00	6.43	9.05	39.71	4	52.60	70.56	54.20	37.01	53.33
Huntsville, Alabama (in middle basin of Tennessee river)	600	14	14.20	15.36	9.80	15.84	55.35	13	59.96	75.62	59.80	42.15	59.38
Knoxville, Tennessee (in upper basin of Tennessee river)	1,000	7	14.52	14.15	8.90	14.01	51.58	6	55.80	74.73	58.62	37.82	56.74
Nashville, Tennessee (on Cumberland river)	533	11	14.33	12.73	11.50	13.22	51.78	6	59.85	76.32	57.42	40.07	58.32
Danville, Kentucky (in Kentucky River basin)	900	14	12.30	11.95	8.29	11.11	43.65	12	56.28	75.58	58.56	37.84	57.07
Louisville, Kentucky	450	7	13.15	12.27	8.90	13.40	47.81	4	55.71	73.90	55.70	37.34	55.70
Bellefontaine, Ohio (near head-waters of Scioto and Great Miami).	1,040	7	10.30	12.09	7.60	8.13	38.12	3	48.87	72.01	51.80	26.25	49.91
Cincinnati, Ohio	580	42	11.17	12.67	9.29	9.83	42.96	36	54.13	75.24	55.21	34.28	54.72
Marietta, Ohio (mouth of Muskingum river)	580	48	10.74	12.09	9.55	9.52	42.50	50	51.08	71.29	52.85	32.84	52.24
Steubenville, Ohio	670	40	10.59	11.88	9.68	9.00	41.15	40	50.90	72.60	52.52	31.22	51.83
Logansport, Indiana (in upper Wabash basin)	600	4	11.33	8.30	10.44	8.07	38.14	5	49.00	73.89	51.51	27.04	50.06
Indianapolis, Indiana (in Wabash basin)	698	12	13.40	11.04	8.05	8.86	41.35	6	49.94	72.64	51.96	28.71	50.06
New Albany, Indiana	553	3	9.35	8.86	9.40	12.22	39.83	4	51.16	73.91	54.63	33.94	53.41
Mattoon, Illinois (in Wabash basin)	740	4	10.95	16.46	8.00	12.62	57.03	.....	.....	.....	.....	.....	.....

a From the Smithsonian tables.

The chief disadvantages to the utilization of power on those northern tributaries of the Ohio which were visited arise from a liability to an insufficient supply of water in summer and fall; from the occurrence of heavy freshets, accompanied often at the close of winter by runs of thick ice, endangering hydraulic works; from the backwater caused by those freshets, which lessens the fall, and remains long according as the descent in the stream below is small and the country drained above is flat; and from the difficulty of securing rock foundation for dams. With reference to this latter objection it may be said, however, that good gravelly beds are common, and with a suitable construction of dam should be entirely safe. The principal application of power on these streams has thus far been in flouring-, grist-, and saw-mills; but on certain rivers, notably the Great Miami and the Beaver, general manufacturing has become well established.

The Ohio river itself presents but one opportunity for the use of water-power on a large scale by ordinary methods, namely, at the Louisville falls, which will be described farther on. A few miles below Pittsburgh the national government has been building a movable dam, known as the Davis Island dam, designed to improve the navigation of the river by assuring at all times a depth of 6 feet above to the city. It extends in two sections from either shore to the island, and with the river unimproved below will have a lift in low water of about 10 feet. If this system of improvement were to be continued down the river as proposed, the lift at the Davis Island dam would be reduced to about 6 feet. In low water, when the dam will be upright, boats will pass through a lock next the right bank. In high water, however, the dam will lie flat on the river-bed, being protected by low sills

from the force of the current, which at such times is very rapid, probably reaching a velocity of from 7 to 9 miles per hour. The river-bed is composed at this locality of sand, gravel, and bowlders, and for the dam an artificial bed of concrete was made. The structure itself consists of a great number of wooden wickets hinged at the base and supported when raised by iron braces, these also hinged at one end to the under face of the wickets and with their lower ends resting in slots. The wickets are raised and lowered from an iron truss bridge formed by bents hinged at the base so as to revolve in a plane transverse to the stream, while the wickets themselves revolve with the stream. In high water the bridge, as well as the dam, rests on the river-bed, so that no obstruction is offered to the current or to the free passage of boats at any point. So long as the dam is in position, or for say seven months in the year, there must evidently be a considerable power going to waste here, although in very low stages of water it would not probably exceed 3,000 or 4,000 theoretical horse-power, even with 10 feet of fall and the entire volume of the Ohio. Works for employing the power thus afforded could, it is said, conveniently be located out of reach of any but extreme rises in the river; but there is at present no settlement at this point, the hydraulic improvements would be expensive, and this, together with the fact that the privilege could be utilized for only so small a portion of the year, and that during much even of that time the full fall could not be realized, would doubtless be serious obstacles to its development.

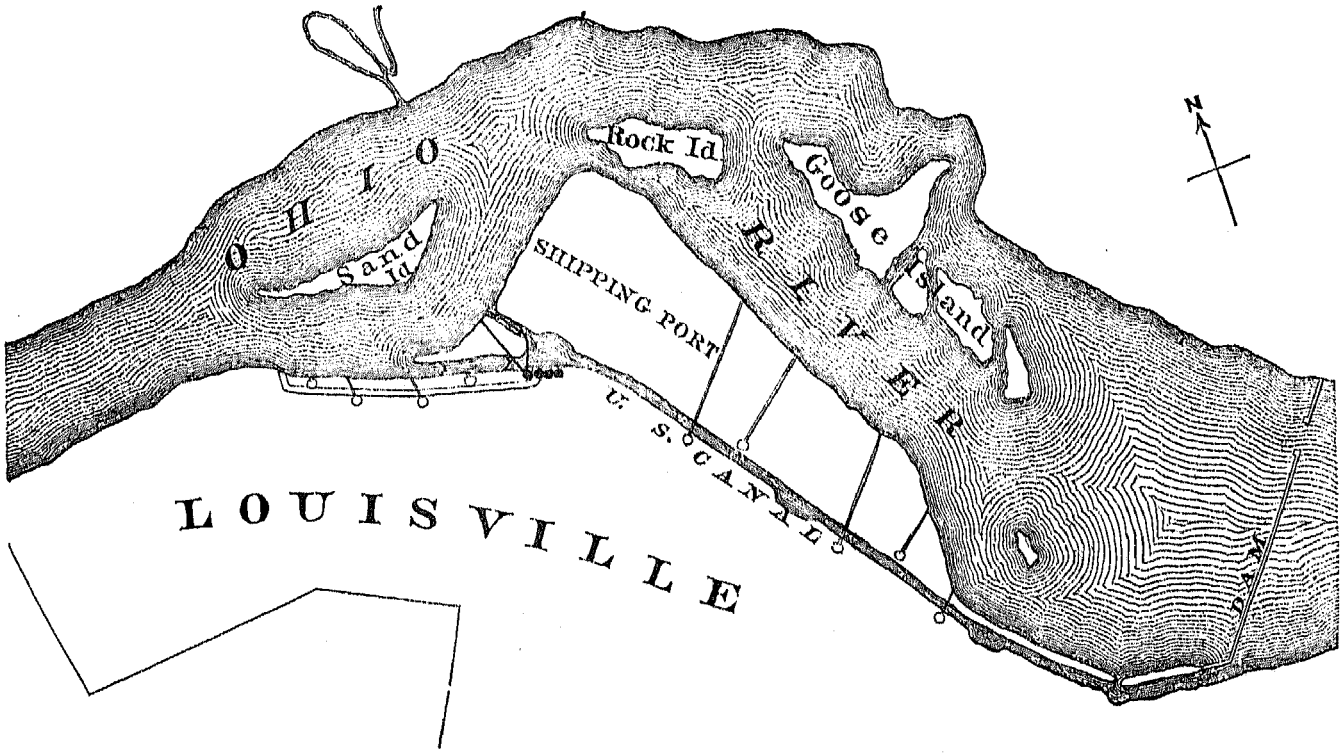
The employment of current-wheels for obtaining power is, of course, possible, and there is said to have been one of these, years ago, on the upper river, but there is no likelihood of their coming into common use here at present; and sufficient has been said regarding their value in another part of this report. The fall in the Ohio is in general slight, and no opportunity exists, as on some western rivers, for diverting water through sloughs across long bends, and so taking advantage of the intermediate descent. This river does not form sloughs of the nature referred to, or "cut-offs", as do the Mississippi, Missouri, Arkansas, and other rivers. At certain points long loops have formed, and at one of these, in the vicinity of Evansville, it is thought possible that protective measures may have to be taken to guard against a cut-off; but usually the projecting points of land which are left have within a rocky shoulder, preventing the actual cutting through of a channel.

Table of elevations on the Ohio river.(a)

Locality.	Distance from mouth of river.	Elevation of low water above ocean-tide.	Distance between points.	Fall between points.	Fall per mile between points.	Remarks.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*	
Pittsburgh	967	701.040				Elevation assumed as 699.20 feet by Mr. James T. Gardner (see *Elevations of Certain Datum Points on the Great Lakes and Rivers and in the Rocky Mountains*).
Mouth of Beaver river	942	671.570				
Steubenville	899	640.518				Elevation assumed by Mr. Gardner as 630.77 feet at low water.
Marietta	796	569.821				
Mouth of Little Kanawha river	784	563.394	598	308.340	0.516	
Mouth of Great Kanawha river	704	514.554				
Portsmouth	614	467.526				Elevation assumed by Mr. Gardner as 470 feet at low water.
Cincinnati	501	430.800				Elevation assumed by Mr. Gardner as 430.74 feet at low water.
Mouth of Great Miami river	480	420.617				
Carrollton	426	403.828				
Louisville falls, head	369	393.900	4	25.700		The descent at the falls proper has been determined by other surveys, and is usually stated as about 26 feet in about 2 miles.
Louisville falls, below foot	365	367.600				
Mouth of Green river	102	319.056	365	92.600	0.254	
Mouth of Wabash river	129	304.313				
Cairo	0	275.000				As reported from the office of the Mississippi River commission, "The zero of the United States engineers' gauge at Cairo, Illinois, is 269.58 feet above mean tide at Biloxi, Mississippi, and the lowest recorded stage of water at that point occurred December 25, 1871, when the surface of the water was 1 foot below the zero of the gauge. Its elevation above mean tide was therefore 268.58 feet. The elevation of mean tide has not been finally adopted [February, 1884], and the above elevations are subject to small corrections."

a The elevations in the third column of this table are taken from Mr. W. Milnor Roberts' report, dated April, 1870, on a survey of the Ohio river—*House Ex. Doc. No. 72, Forty-first Congress, third session*—and can not be regarded as entirely correct; Major William E. Merrill, Corps of Engineers, has discovered an error of 8 feet in the elevations between Pittsburgh and Wheeling.

As shown by the data of the preceding table, the total descent in the Ohio, at low water, from Pittsburgh to Cairo, is not far from 430 feet in 967 miles, an average of about 0.44 foot per mile for the whole distance. The river gradually increases in width at low water from 1,000 feet in its upper course to about 2,500 feet near the mouth. At such a stage it is described as a succession of long pools and ripples, with current alternately sluggish and rapid. A large commerce is carried on by means of steamers, barges, and other craft, but navigation is seriously interfered with by low water, and continuous communication from Cairo to Pittsburgh, for boats of considerable draught, has hitherto been practicable during only about four months in the year. On the upper river the bars are mainly of gravel, and, on the lower river, of shifting sand.



Sketch of the Ohio River at Louisville, showing Proposed Plans for obtaining Water-power.

There are usually three important rises in the Ohio during the year—one in February, caused by rains and melting snow; one in May or June, due to heavy rains; and a third occurring in late fall, not very regular in the date of its appearance, and caused by rains. The first of these is the heaviest, and sometimes produces widespread destruction of property. The ordinary oscillation, in general along the course of the river, between high and low water, is given by Humphreys and Abbot as not over 25 feet, while the extreme is placed at about 45 feet; but at particular localities these figures are exceeded. Thus, at the mouth the extreme range is over 50 feet; in February, 1832, the river was 64 feet above low water at the foot of the Louisville falls, and in February, 1884, it reached a height at Cincinnati of 71 feet 0.75 inch above low water. The river commonly freezes about Christmas, and continues frozen sometimes as long as four weeks, and in 1855 remained frozen at Louisville for 65 days. On the rising of the streams, toward the close of winter, great fields of floating ice are brought down by various tributaries of the Ohio, especially by the Allegheny and Monongahela, though the ice from these latter rivers is well broken up against the bridge-piers at Pittsburgh.

POWER AT LOUISVILLE.

For reasons elsewhere stated, the Louisville falls were not visited; but as it seems hardly permissible to neglect a description of them in connection with the Ohio river, a few facts will be briefly mentioned regarding them, taken mainly from various reports already made upon the subject. These falls, the only ones upon the river, are situated 600 miles below Pittsburgh, 135 miles below Cincinnati, and about 370 miles above the mouth. They consist of a series of rapids, formed by irregular ledges of limestone rock, extending a distance of 3 miles, and covering in 2 miles a fall, in low water, of about 26 feet, four-fifths of which occurs in about 1 mile. At the head of the rapids the government has a low dam reaching across the stream, with the exception of certain gaps, built part of the way of a movable pattern, and designed to be extended of the same type. In connection with this improvement a canal some 2 miles in length follows down the Kentucky side of the river, and accommodates boats in passing the rapids.

Louisville is a wealthy and beautiful city of about 125,000 inhabitants, enjoying a large trade and having important manufacturing interests. The great power existing in the river immediately before the city, and the advantage which would accrue to the latter from its utilization, have not been overlooked, and various plans for its development have been proposed and discussed. But while the size and value of the power are evident, the cost of such improvements as would make it actually available for use appears so large as to render doubtful the receipt of a direct profitable return on the necessary outlay of capital. So far as ascertained, no detailed and complete surveys and estimates have been made by which to show the probable expense of improvement under any of the different plans suggested, and until this is done the real practicability of the work must remain a matter of conjecture.

Four leading designs for the development of the power, as outlined by Morris S. Belknap, C. E., in a paper read before the American Society of Civil Engineers in May, 1873, are as follows:

(1.) By means of a hydraulic canal running approximately parallel to the canal now in use for navigation, the mills to derive their supplies from the former and to discharge either into a tail-race extending parallel to it, or directly into the river.

(2.) To draw for the mills from the government canal, discharging in either of the ways above described.

(3.) To draw from a canal carried as a continuation of the government canal, discharging directly from each mill into the Ohio.

(4.) To draw from the government canal at its lower end for the supply of turbines and other hydraulic machinery to be stationed there, the power developed to be distributed by wire cables to the various mills and factories.

Still another plan is said to have been considered, namely, the carrying of a hydraulic canal off into the city, or around it, at a considerable distance from the river.

Altogether there has been expended on the navigation canal more than $4,000,000, and by comparison the necessarily great expense involved in the first plan is opposed to its adoption. Notwithstanding this fact, it has important advantages, and is regarded by prominent authority as the most practicable of any of the designs. The second, third, and fourth methods of improvement require the withdrawal of water from the government canal, for which act permission must be obtained. The transmission of hydraulic power by cables, while in successful operation at such points as Lockport and Rochester, is there confined to small powers, and the experience at the latter point in transmitting large powers, say of 200 or 300 horse-power, is unfavorable to that system, while in an enterprise of such magnitude as the utilization of the Louisville falls there should exist the ability to supply powers of large as well as of small size. By means of a low wing-dam of rip-rap next the Indiana bank sufficient water is diverted to furnish power, through the medium of a wire cable, to a mill on the bluffs, and there is reported to be a trifling use of power on the Kentucky side of the river; nevertheless, the Louisville falls are essentially unemployed for manufacturing-purposes.

It will naturally be asked: How large is the power to be obtained from the falls of the Ohio? But to this question perhaps no very definite answer can now be given. The volume of the Ohio at Louisville, during an ordinarily low stage, was stated by Mr. Belknap to have been shown by observation to be about 7,750 cubic feet

per second, corresponding, with the full fall of 26 feet, to about 22,000 theoretical horse-power. But of this volume a certain portion must be required for lockage in the government canal, while another and much larger portion must escape through the gaps in the dam. Just what remainder there would be available for power is not accurately known. In an estimate made by Mr. John Zellweger, constructing engineer of Louisville in 1876, it was roughly assumed that one-third the entire flow of the stream at such a stage could be utilized, yielding say 7,600 theoretical horse-power. For nearly all the year the discharge of the river is greatly in excess of the figures given, but, owing to the fact that as it increases from low stages the level of the water at the head of the falls rises much less rapidly than that at their foot, the net fall is thereby reduced. This action is largely due to the contraction of the river at the "narrows", some 60 miles below Louisville. As stated by Mr. Zellweger, "The fall, or difference in water-level above and below the locks, does not decrease regularly as the river rises, but at first decreases slowly until the upper gauge marks about 7 feet; then it commences to decrease more rapidly until the gauge indicates about 14 feet. Above this the fall is reduced slowly, and remains nearly permanent for the high stage of water. In the year 1875 the upper gauge read off less than 7 feet, and the fall was over 22½ feet, for 126 days; less than 12 feet, and the fall was 6¾ feet (or over), for 300 days; less than 14 feet, and the fall was 3½ feet (or over), for 327 days." The year mentioned was one of unusual rainfall in this section of the Ohio valley. The fall was less than 6 feet for about 25 days in March, a total of 25 days in July and August, 4 days in December, and 3 days in April, in the two latter months the diminution below 6 feet being small in amount.

Mr. Belknap gives 12 feet by the gauge above the falls as the stage at which nearly all fall is lost and the water-surface has its normal slope, the rise below the falls being about three times as rapid as above them; and states that, as the average of years of observation by authorities in charge of the government canal and of the water-works, the following differences of level have been found to exist: For 21 days in the year, practically no fall; for 11 months and 9 days, 6 feet and over; for 9 months and 21 days, 13 feet and over; for 3 months and 17½ days, 26 feet.

For between 9 and 10 months in the year, therefore, a fall of 13 feet and upward is available. During that period there is, of course, a wide variation in the volume of the river, though no data are at hand showing directly its value in cubic feet. But, by a consideration of the probable curve of discharge of the Ohio at this point, the range may be roughly estimated to be from 8,000 to at least 130,000 cubic feet per second. (*a*) Assuming, however, for the lower limit the figures already quoted from Mr. Belknap's paper, we have a variation from 7,750 cubic feet per second in what is termed an ordinarily low stage with 26 feet of fall, to 130,000 cubic feet per second, with say 13 feet of fall; or from 22,000 to 192,000 theoretical horse-power. Reckoning an efficiency of 75 per cent., this corresponds to a range, in round numbers, of from 17,000 to 144,000 effective horse-power. That is to say, excluding from two to three months of highest water, in which the fall varies from 13 feet down to practically nothing, and for half of which time it would probably be found less than 6 feet, the entire volume of the river would yield, in the average of years, an effective power ranging, for different stages, between 17,000 and 144,000 horse-power. But since, as has been noticed, a large proportion of the discharge must, under the present arrangement of dams, run entirely to waste, while part of the balance is necessarily reserved for lockage, it is evident that the figures stated must be greatly reduced before arriving at the values pertaining to practical utilization of the falls for hydraulic purposes.

The fact that there is a certainty of interruption during a part of the year by high water, rendering necessary the introduction of auxiliary steam-power by all important establishments, is, without doubt, unfavorable to this site. It seems unquestionable, also, that the expense of suitable hydraulic works would be heavy. Nevertheless, when the location of the power is considered, at a great, wealthy, and rapidly growing city, upon a river supporting a magnificent traffic yet in its infancy, its importance becomes apparent; and even if the enterprise of developing it were to afford but a very slight direct profit upon the required investment, the indirect advantages which would result from the building up of large manufacturing works can not be doubted. The question, however, as to how great an outlay could be endured without rendering it impossible to lease power at a price which would admit of successful competition with similar undertakings elsewhere, and especially with steam-power derived from cheap coal, is one of finance, and one demanding in its decision exercise of thorough knowledge and sound judgment.

TRIBUTARIES OF THE OHIO RIVER.

THE ALLEGHENY RIVER.

Drainage areas.

	Square miles.
At Port Allegheny	219
At Olean, below Olean creek	1,096
At Salamanca	1,556
At Warren, below Conewango creek	3,045
At Franklin, below French creek	5,667
At Pittsburgh, mouth of river	11,107

a The drainage area above Louisville is about 91,000 square miles. On this area the average rainfall may be estimated to be, in spring 10 inches, in summer 11, in autumn 9, in winter 11, and for the year 41.

This river, the principal one in the formation of the Ohio, takes its rise in Potter county, northern Pennsylvania, close by the sources of the Susquehanna and Genesee. Thence to the junction with the Monongahela at Pittsburgh the course pursued is very irregular. The stream first flows westerly into McKean county, and then, making a bend to the northward, passes into New York state and across the southern part of Cattaraugus county. At Salamanca, in that county, the direction of flow turns toward Pennsylvania again, and thence to Pittsburgh its course may be called southwesterly, although it is not maintained with much persistency. The length of the Allegheny, following its bends, is not far from 325 miles, and the area of its drainage basin is, in round numbers, 11,000 square miles. The section of country thus comprised lies largely upon the western slope of the Alleghany system of mountains, and possesses, in the main, an extremely rough and broken surface, made up of high hills or mountains, the summits of which reach, in southern New York, elevations of 2,500 or 3,000 feet above tide, while between the hills are proportionately deep valleys. As the limits of the basin to the west of the main river are approached, the mountainous character is lost, though the surface is still hilly or rolling.

Pittsburgh, at the mouth of the river, has grown with remarkable speed, and had in 1880 a population of 156,000. Scattered along the course of the river above are a number of cities, boroughs, and villages, of considerable importance, the principal among them being, in order passing up stream, Freeport, population 1,600; Kittaning, 2,600; Franklin, 5,000; Oil City, 7,300; Tidioute, 1,300; Warren, 2,800; Salamanca, 2,500; and Olean, 3,000. Much of the country naturally tributary to the river, however, and especially that lying to the east and southeast of its upper course, is but very sparsely settled. Means of communication by railroads are tolerably good, and along the immediate course of the river such routes form a continuous line from the mouth nearly to the head-waters, though not existing under one management. Great activity pervades this portion of Pennsylvania on account of the many enterprises for developing its natural resources, which are very great. The Allegheny river runs through the midst of the oil region. Many of the hill-sides fairly bristle with derricks erected over the wells; the product is conveyed great distances in continuous lines of pipe, and in certain localities, as for instance in the vicinity of Olean, may be seen large numbers of iron tanks dotting the fields for a long distance and used for storage. The back country is clothed with valuable forests of timber, which is cut and rafted down the streams in immense quantities. Formerly pine was the principal variety cut, but now, along the upper waters of the main stream at least, the supply of this has become much reduced, and hemlock is the chief reliance. The lumber rafts are made up of "pieces" containing from 20,000 to 30,000 feet each; from Olean the rafts usually start with from 100,000 to 150,000 feet, and are from time to time "doubled up" as they get farther down the river. Besides oil and timber, the section drained by this river is rich in accessible quarries of limestone and building-stone, and in deposits of coal, iron, and glass-sand. The undertakings aimed at developing the particular resources mentioned give rise in turn to numerous other industries; various new railway lines are projected, and the cities are filled with an eager, shifting throng of managers, projectors, and speculators.

For about half the year the river is navigable for small steamers to Franklin, 123 miles above Pittsburgh. The actual amount of transportation by water, however, is small, and the freight is mainly confined to oil and coal. Within a few years the course from Olean down to within 30 miles of the mouth has been examined and in part surveyed by Mr. Thomas P. Roberts, United States assistant engineer, in order to determine its value for navigation, and the best method of improving it. (*a*) The plan proposed for the present is to clear the channel of obstructing rocks, and to secure sufficient depth at shoals by constructing wing-dams, the estimated cost of the improvement for the 188 miles below Warren being $133,650. The sum of $10,000 having been appropriated by Congress, work was begun upon the lower river in the summer of 1879.

Nothwitstanding its importance as a river which receives the drainage from a wide extent of country, much of which is of an elevated and even mountainous character, the Allegheny has comparatively small value for water-power. The area of the entire basin, as has been said, is about 11,000 square miles; but if we assume that by improvements navigation may be established as far north as Warren, there remains above that point but little more than 2,000 square miles to contribute by its drainage to the volume and available power of the main stream. The fall in the river is also too small in that section to admit of the establishment of many water-privileges. Of the 325 miles' entire length of the river, 255 miles are included between Olean, New York, and the mouth; but the total fall in this interval, comprising about 80 per cent. of the whole course, is only 725 feet, or an average of less than 3 feet per mile. The descent is accomplished without abrupt pitches, and even with few rapids having fall of much consequence. Between Olean and the mouth of the Kiskiminetas, 30 miles above Pittsburgh, the greatest amount of natural fall on any ripple of less than 1,000 feet length is 3.9 feet in 850 feet, at Patterson's falls, 29½ miles below the mouth of French creek; and upon longer ripples the largest total fall is 11.23 feet in 6,900 feet, at McGinnis' rapids, about a mile below Patterson's falls. (*b*) This river, in fact, presents the unusual feature of having a greater general slope in its middle and lower, than in its upper course. The section above Olean was described by lumbermen as sluggish far above toward the source, and in the first 25 or 30 miles above, the elevations obtained indicate an average slope not probably much, if at all, exceeding 1.5 foot per mile. In the succeeding 23 miles below Olean to

a See *House Ex. Doc. No.* 21, *Forty-fifth Congress, third session*, and *Senate Ex. Doc. No.* 89, *Forty-sixth Congress, second session.*

b Roberts' reports of surveys.

Salamanca the mean descent is about 1.8 foot per mile, thence to Corydon 4 feet per mile, and from Corydon to Warren 4.7 feet per mile; from Warren toward the mouth the rate of descent gradually diminishes, yet remains in general greater than for the section above Salamanca.

Table showing the fall in the Allegheny river.

Locality.	Distance from mouth of river.	Elevation of water-surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority and remarks.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Port Allegheny	a 283.00	b 1,482.00				
			57.68—	28.10	2.00—	Elevation on Buffalo, New York, and Philadelphia railroad, as given in report upon *Levels above Tide, Second Geological Survey of Pennsylvania.*
Olean	254.90	1,424.32				
			42.83	23.11	1.85	In the report by Mr. Thomas P. Roberts, United States assistant engineer, the elevation at Olean is given as 1,407.98 feet, having been taken from the list of elevations prepared in connection with the Pennsylvania geological survey. According to the profiles of the New York State canals, however, the elevation is 1,422.25 feet + mean low tide at Albany, which altitude has here been adopted and referred to mean ocean-level in New York harbor by adding 2.07 feet, the difference given at the Coast Survey office.
Salamanca	231.79	1,381.49				
			92.72	23.13	4.01	
Crest of Corydon dam	208.66	1,288.77				
			98.77	21.06	4.69	
Warren suspension bridge	187.60	c 1,100.00				
			75.70	22.58	3.36	Elevations obtained, as at Olean, by adding 16.34 feet to the figures given by Mr. Roberts.
Head of Tidioute island	165.02	1,114.21				
			74.35	21.77	3.42	
Hemlock island	143.25	1,039.86				
			61.80	20.35	3.04	
Franklin, mouth of French creek	122.90	978.06				
			278.86	122.90	2.27	
Pittsburgh, mouth of Allegheny river	0.00	699.20				Low-water surface in river (see *Elevations of Datum Points*, as obtained by Mr. James T. Gardner for the *Geological Survey of the Territories*).

a Portion above Olean obtained by map measurement. b In this case elevation of rails above tide. c Estimated.

In that portion of its course lying north of the Pennsylvania boundary the river is bordered by wide bottom-lands, varying from half a mile to two or three times that distance in breadth between the hills, and in places, as in the vicinity of Olean, subject to partial overflow during freshets. At Corydon and below the valley becomes more contracted, and at times the hills rise with steep slopes directly from the water. The bed in this upper portion is mainly gravel. From Olean to Jamison's falls, a few miles below Salamanca, it is almost exclusively composed of this material or of gravel and sand. At Jamison's falls loose rocks appear in the stream, and at Limestone falls, 13 or 14 miles below, and within a few miles of the New York and Pennsylvania boundary, the bed is underlaid by solid limestone rock, and there is a descent in the water-surface of 3.84 feet in 650 feet. Thence down stream loose rocks become abundant, and are usually to be found at the shoals, more or less completely embedded in the gravel.

The country drained by the upper course of the Allegheny is said to be quite well supplied with springs, the waters of the river are clear, and are tolerably well sustained in volume, considering that there are no artificial reservoirs and no lakes or swamp-lands of importance to regulate the flow. The natural result to be expected from the clearing of the timber and the settlement of the country is being realized, however, and the discharge appears to be growing more variable and unreliable than formerly. The lowest pitch is commonly reached in the early part of September, but there are few data to show the actual volume of water flowing in low stages. Mr. Roberts, in his report upon the reconnaissance of the lower river, made in 1878, states that he gauged the discharge at a ripple 19.2 miles below French creek and found it to be 143,900 cubic feet per minute, or say 2,400 cubic feet per second. The river was at that time about 3 inches above its lowest stage, in falling to which it was estimated that the discharge might be reduced by as much as 20,000 cubic feet per minute, or 330 per second. Mr. Roberts also mentions that the volume of the river near Pittsburgh is said to sink as low as to 80,000 cubic feet per minute, or 1,330 per second, in the lowest stages, but expresses the opinion that more exact measurements would perhaps show a closer agreement than exists between the data here given. These results may be thus presented:

Data concerning the discharge of the Allegheny river.

Locality.	Stage of water.	Drainage area.	Flow per second.	Flow per second per square mile.	Remarks.
		Sq. miles.	*Cubic feet.*	*Cubic feet.*	
Roberts' Run ripple, 19.2 miles below French creek.	Three inches above lowest water marks.	6,020	2,400	0.40	Gauging made in 1878 by Thomas P. Roberts, United States assistant engineer.
Do	Lowest water		2,070	0.34	Roughly estimated from the above gauging by Mr. Roberts.
Near Pittsburgh	do	11,100	1,330	0.12	Volume said to be reached at times.

The elevated region about the upper course of this river is often covered in winter by a very deep body of snow, which not infrequently attains a depth of 3 feet on a level in the more accessible districts, and not unlikely much more than that among the mountains. The melting of this mass of snow produces a heavy spring freshet, usually in March, and other rises are also caused by the rains of early summer and of autumn. These freshets affect the river in a varying manner, according to the conditions existing in different parts of its course. Thus, in the comparatively sluggish portion above Salamanca, the stream is described as rising gradually, attaining in the vicinity of Olean usually a height of about 10 feet above low water and submerging the flats to depths of from 1 to 5 feet. The highest rise of which any thing could be learned was that of 1865, reported to have been between 21 and 22 feet at Portville, a few miles above Olean, and at the latter point there was a rise of 15.8 feet in 1873. As the river here rises rather slowly, so it also runs out slowly, a high stage of water sometimes holding for two weeks and stopping the mills near Olean. Farther down stream, on the other hand, the river is regarded as rising and falling quite rapidly, and along the section on which Corydon is situated, where the slope is twice as great as above Salamanca, the valley lands are overflowed only at long intervals and during extremely high freshets.

Ice is a powerful and destructive agent on this river. It forms very thick, sometimes 30 inches at Franklin, and when forced out by a rise in the stream, meeting but few obstructions to reduce it to fine pieces, becomes gorged and piled up in bends and on shoals. Generally the ice-dams thus made soon go out, but large masses of cake-ice are left on the banks, to which they become firmly cemented; in some subsequent rise they float off, carrying with them gravel, large stones, and even sometimes, it is said, tearing out trees. Mr. Roberts states that "at Kinzua, in the upper wide bottom-land region, 54½ miles below Olean, an ice-gorge some years ago dammed the river up, and caused it to flow in a circuitous route a mile or more through the bottoms, where it washed off the soil of cultivated fields and caused much damage to property before finally returning to the channel". It is evident that such heavy ice-runs must be a menace to dams scattered along the river, yet they are maintained in security at a number of points, and every additional one tends to mitigate the evil.

Water-power is employed on the Allegheny river at Corydon, Salamanca, Portville, and at several scattered points above, its use being confined mainly to saw-mills. The number of these mills along the river was formerly greater than now, but has decreased with the clearing away of much of the timber, although there has at the same time been an increase in the size of those concerns continuing operations. Although it is not probable that the power of the river could now be developed and profitably utilized to much extent for sawing lumber, yet the location of its course seems very well suited to the manufacture of wood-pulp, paper, and various articles of wooden ware. Wood-pulp is now manufactured at Salamanca and Corydon by water-power; at the latter place the material employed is principally poplar and basswood, of which there is said to be an abundance in the vicinity. At each of the three points which have been mentioned in particular as sites where power is utilized, the dams are low structures, built of piles, which is indeed said to be the prevailing construction on the streams of this section.

The extent of utilization of the extreme upper river may sufficiently well be learned from the table of utilized power; personal examinations were carried but a few miles above Olean, New York. At that place the stream is about 200 feet wide, shallow, with a moderate current and gravelly bed. The banks are perhaps 10 feet high, succeeded to the south or left at a short distance by hills, while on the north side there stretches out a wide level valley, in which the village is built. A few miles up stream, at a point locally known as Weston's Mills, in the town of Portville, the firm of Weston Brothers has a large saw-mill, and a second, 3 miles still above, at Mill Grove. At the latter point a fall of about 5½ feet is obtained, and a gang-saw, a "slabber", and a circular saw are run, from 5,000,000 to 6,000,000 feet of hemlock lumber being sawed annually. The supply of this variety of timber is large, and it is being felled all the way from Olean to the head of the river; accessible supplies of pine, however, along the course are very limited, and the Westons are the only firm cutting that kind of timber, though formerly lumbering operations were confined to it almost exclusively. At the lower mill the sawing is about half in pine and half in hemlock, and amounts, on the average, to about 12,000,000 feet per annum, ranging from 10,000,000 up to 17,000,000. Steam-power is used in a planing-mill, a shingle-mill, and some other works, but substantially all the sawing is done by water-power, and there are operated 2 flat gang-saws, 2 "slabbing gangs", 2 "English mills", and other machinery. The fall is about 5½ feet, never exceeding 6, and it is estimated that not far from 250 horse-power is employed. The mill is run throughout the year, and both night and day when the water-supply is sufficient. This is the case for from six to nine months in the year, but for the remainder of the time there is more or less shortage. During the dry season of 1882, for some months it was possible to run only about one-half the works, and that for but twelve hours per day. The storage is sufficiently large, extending back 3 miles at the lower privilege and 10 miles at the upper, to control at such times the flow of the stream, the night-water just about filling the lower pond. The dam is 220 feet long and not over 5 feet high. It consists of piles ranged across the stream in three rows 8 feet apart. On the tops of the piles are capping-pieces, and, over all, planking, giving a single slope, and that down stream. The front and back of the dam are vertical and faced with planking, the planks running horizontally; the facing of the back is carried down probably 5 feet into the river-bed, which is composed of gravel; that of the front (fastened to the inner surfaces of the piles) extends only to the bed. The interior of the structure is filled in with loose stone.

The next use of power is met with at Salamanca, between 25 and 30 miles farther down stream. The river still maintains a gravelly bed and runs shallow, but has increased in width to from 300 to 350 feet and is confined between banks of fair height. The village has 2,500 inhabitants, and lies on the right bank, in a valley not apparently more than half or three-quarters of a mile wide, and shut in by high, partially-wooded hills. The dam is somewhat convex up stream, and runs out in two sections to an island, with a total length of about 415 feet. It is a pile structure, similar in construction to that already described, but with a slope each way from the crest. The front slope is 16 feet long and covered with 3-inch planking; it decreases in height above the river-bed from 7½ feet at the crest to 3 feet at the overfall, and serves as an apron. The back slope is continued down to or into the river-bed, and near the foot the space beneath is filled in with brush and stone; otherwise the space under the covering of the dam remains open. There are five rows of piling, about 6 feet apart in the direction of the stream, and penetrating probably an equal distance into the bed, one row beneath the crest and two on each side; transversely to the stream the piles are driven at intervals of about 8 feet, and crib-work abutments protect the ends of the structure. This dam was erected at a cost stated to have been $3,000; it stands securely and is reasonably tight.

A race about 75 feet wide leads down the south bank perhaps a third of a mile to the mills owned by Messrs. Hall & Whitmore. A fall averaging say 7 feet, with a maximum of about 8, is obtained, and an estimated total of 200 horse-power is employed in works for the manufacture of lumber and wood-pulp. Fifteen tons of pulp are ground per week, and are shipped to Rochester, Cleveland, and other points. The saw-mill has a capacity of 100,000 feet per 24 hours, and actually manufactures from 5,000,000 to 6,000,000 feet of lumber yearly; one gang of 26 saws, one circular saw of 6 feet diameter, three planers, and a lath-mill are run, besides other small machinery. Pine timber is obtained 10 miles above Bradford, Pennsylvania, and hemlock at various points. Pine has hitherto been the principal variety sawed, but here, as elsewhere, will soon be entirely supplanted by hemlock. The supply of water suffices for the present demands of the works for about eight months in the year. An occasional stoppage of the mills is forced in winter by anchor-ice, here known as slush-ice, and more or less trouble is also experienced for three or four weeks during the year from the backwater resulting from freshets.

Estimate of power at Salamanca.

Stage of river.	Rainfall on basin.					Drainage area	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*7 feet fall.*	
Low water, dry year	9	11½	10	0½	40	1,556	250	28.40	200	200±
Low water, average year							320	36.35	250	
Available 10 months, average year							500	56.80	400	

The Buffalo, Pittsburgh, and Western railroad follows down the river from Salamanca to Oil City, crossing several times. For 40 miles above the New York and Pennsylvania boundary the land adjoining the river for half a mile in width on each side belongs to the Seneca Indian reservation; below the boundary, in Pennsylvania, a strip 2 miles long and half a mile wide, lying on the right bank of the river in the vicinity of Corydon, is included similarly in the Cornplanter reservation. On these reservations the Indians are said to live in a poor, shiftless fashion, doing but little to improve their lands and engaging in no manufacturing industry whatever.

From Salamanca to Corydon ripples appear here and there in the stream, the bed continues gravelly, and one bank or the other is often low. At Corydon the valley is similar to what has been described at points above, though somewhat narrower. The lands adjacent to the river are here seldom overflowed and are very valuable for farming, being finely suited to the raising of grass and the various grains. Beyond rise high hills, frequently with steep slopes; these are wooded, but most of the larger timber has been cut away from the immediate valley sides. The settlement in this section is very sparse, and the entire township of Corydon contained in 1880 but 335 inhabitants. At the village of the same name the river is obstructed by a low dam not over 4 feet high, built about the year 1865 at a cost estimated not to have exceeded $4,000. The main structure is about 350 feet in length, and, like the dams farther up the river, is built of piles, running across the river in this case in four rows 8 feet apart; the cross-section is similar to that of the dam at Salamanca, except that there is one less row of piles. With 1-foot flash-boards, or "brackets", as they are also called, a fall of about 6 feet is obtained at the mills, which are on either side of the river. On the west bank are Leach's saw-mill, not running at the time it was visited, and Dalrymple's mill, at which probably 1,000,000 feet of lumber—pine and hemlock—is sawed yearly. On the east bank power is used as follows: By Sunderlin & Payne for a saw-mill and for the manufacture of fork-, hoe-, rake-, and broom-handles and dowels, the firm running 6 circular saws, varying from 12 inches to 5½ feet in diameter, and using about 1,000,000 feet of lumber yearly, largely maple and ash; by the Jamestown Wood Pulp & Paper Company, having an average daily production of about 1½ ton; by F. J. Morrison for a saw-mill at which probably 1,500,000 feet of umber is sawed annually; and by Messrs. F. J. & P. Williams for a shingle-mill with an estimated capacity for

manufacturing 1,500,000 shingles per year. Spokes, hubs, and staves are also largely manufactured in the village, though not by water-power. The power at the privilege described is sufficient for the full supply of the mills grouped around it for only about four months in the year. The volume of water carries ice clear of the dam, and very little hinderance is suffered from backwater.

Estimate of power at Corydon.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*6 feet fall.*	
Low water, dry year	0	11½	10	9½	40	1,814	290	32.94	200	350±
Low water, average year							380	43.17	260	
Available 10 months, average year							580	65.89	400	

There are thought to be other sites on this section of the river as available for improvement as the one described, A few miles below the village a part of the river is said to be controlled by a dam running out from one bank to an island, but the use of power is unimportant, and no other developed privilege below Corydon was reported. From that point down to Kinzua, at the mouth of Kinzua creek, the valley is narrow, apparently seldom more than a quarter or a third of a mile wide, and though much of the way the river runs near the hills, yet at least one bank is usually low. There is a fair current, with occasional ripples and islands. Just below Kinzua the hills shut in, and at points rise steep and wooded directly from the river. The valley continues contracted, the flats narrow and disconnected, until, at Warren, there is again a widening. This place is prettily situated on the left bank, on a level terrace stretching back a short distance to the hills.

In the following table is given a list of those ripples between Olean and Warren on which the fall is not less than 3 feet. The river below Warren being navigable, though only for a small portion of the year to that point, and its improvement for navigation, at a moderate outlay, being considered practicable, that section will not here be assumed as available for water-power:

Estimate of power at the principal ripples on the Allegheny river between Olean and Warren.(a)

Locality.	Drainage area.	Distance above Warren.(b)	Length of ripple.	Fall on ripple.	Theoretical horse-power per foot of fall, based on average flow for the 24 hours.		
					Low water, dry year.	Low water, average year.	Available 10 months, average year.
	Sq. miles.	*Miles.*	*Feet.*	*Feet.*			
Ripple below Salamanca	1,550	43.2	1,200	3.32	28	36	57
Sunfish	1,670	37.1	1,050	3.03	31	40	61
Gravel bars	1,740	28.1	800	3.37	32	41	64
Limestone falls	1,784	25.4	650	3.84	33	43	66
Corydon (dam and ripple)	1,814	20.8	600	6.31	33	43	66
Gilman's bar	1,872	16.1	500	3.02	34	44	68
Harrison's lower ripple	1,923	13.3	800	3.42	35	45	70

a List of ripples taken from reports of surveys by Thomas P. Roberts, United States assistant engineer.
b For distance above Pittsburgh add 187.7 miles.

TRIBUTARIES OF THE ALLEGHENY RIVER.

The principal affluents of the Allegheny river, as regards extent of drainage area, are the Conewango and French creeks on the west side, and the Clarion and Kiskiminetas rivers on the east. Aside from the main river, the examinations made in this section were confined to the two first-mentioned tributaries. Some information concerning the Clarion and Kiskiminetas is contained in the report, already referred to, of a reconnaissance of the lower Allegheny, from which it appears that in a dry season those streams, in common generally with the tributaries entering the main river from the east, are very poorly sustained in volume, and in that respect are unfavorable to use for water-power. Thus, at the time of his examination, made in October, 1878, Mr. Roberts roughly estimated the discharge of the Clarion river during the low stage then prevailing to be not more than one-twentieth that of French creek, though its drainage basin is greater by some 50 square miles. The Kiskiminetas also was found very low, its discharge being estimated as less than 90 cubic feet per second, or about an eighth that of French creek at the same period; yet the former drains 1,800 square miles and the latter only about 1,130.

Drainage areas of tributaries of the Allegheny river.

Stream.	Square miles.	Stream.	Square miles.
Oswayo creek	245	French creek	1,130
Olean creek	150	Clarion river	1,184
Great Forks creek	130	Red Bank creek	546
Tunegawant creek	178	Mahoning creek	394
Conewango creek	890	Crooked creek	265
Tionesta creek	446	Kiskiminetas river	1,799
Oil creek	200		

Table of altitudes on various tributaries of the Allegheny river.

Stream.	Locality.	Distance from mouth of stream.	Elevation above tide or above ocean-level.	Remarks.
		Miles.	*Feet.*	
Olean creek	Hindsdale, New York	8.5	1,456	Elevation of rails at station above tide, corrected from levels of Buffalo, New York, and Philadelphia railroad.
Do	Mouth	0.0	1,424	Water-surface above mean ocean-level.
Great Forks creek	Ellicottsville, New York	11.0	1,548	Water-surface in Great Valley creek above ocean-level, by profile of Rochester and State Line railroad.
Do	Mouth	0.0	1,380	Water-surface above mean ocean-level.
Tunegawant creek	Bradford, Pennsylvania	10.5	1,444	Rails at station above ocean-level, corrected from Finch's profile, Bradford branch of New York and Erie railroad.
Do	Mouth	0.0	1,400	Water-surface above mean ocean-level.
Tionesta creek	Sheffield	37.0	1,337	Rails at station referred to mean tide at Baltimore, corrected from levels of Philadelphia and Erie railroad.
Do	Mouth	0.0	1,091	Water-surface above mean ocean-level.
Oil creek	Titusville	10.5	1,194	Rails at station above mean ocean-level, by profile of Pittsburgh, Titusville, and Buffalo railroad.
Do	Mouth	0.0	1,002	Water-surface above mean ocean-level.
French creek	Lebœuf	58.2	1,217	Rails at station referred to mean tide at Baltimore, corrected from levels or Philadelphia and Erie railroad.
Do	Meadville	20.0	1,080	Rails at station above ocean-level, by profile of Atlantic and Great Western railroad.
Do	Mouth	0.0	978	Water-surface above mean ocean-level.
Clarion river	Ridgway	73.5	1,393	Rails at station referred to mean tide at Baltimore, corrected from levels of Philadelphia and Erie railroad.
Do	Mouth	0.0	871±	Water-surface above mean ocean-level.
Red Bank creek	Brookville	40.7	1,235	Rails at station referred to ocean-level, by levels of Bennett's Branch railroad.
Do	Mouth	0.0	830±	Water-surface above mean ocean-level.
Kiskiminetas river	Johnstown on the Conemaugh	64.0	1,184	Rails at station above mean ocean-level, by Pennsylvania Railroad levels.
Do	Blairsville	37.5	965	Rails at Pennsylvania canal above mean ocean-level, by Pennsylvania Railroad levels.
Do	Mouth	0.0	754±	Water-surface above mean ocean-level.

NOTE.—The above table does not furnish the actual fall in the water-surfaces of the various streams, and is simply intended to convey a rough idea of the descent along their courses. The distances given are only approximate, having been obtained by map measurement to a not very large scale. The elevations above the mouths have been taken from the report on *Levels above Tide, Second Geological Survey of Pennsylvania.* The elevations of water-surface at the mouths have been estimated as nearly as possible from the results of surveys by Mr. Thomas P. Roberts, as given in his reports, correcting those results, however, to agree with the elevations adopted for the New York state canals; the correction which has been applied consists in adding 16.34 feet, as already explained in connection with the table of altitudes for the main Allegheny river. Below Franklin the elevations at the mouths of the tributaries have been obtained by subtracting from the assumed elevation at the mouth of French creek the fall as shown by surveys of the Allegheny Valley railroad, stated by Mr. Roberts in his report of December, 1878 (*House Ex. Doc. No.* 21, *Forty-fifth Congress, third session*).

Conewango creek.—The source of this stream is in the northeastern part of Chautauqua county, New York, within 10 miles of lake Erie; thence the course is irregular, but on the whole southerly, into Warren county, Pennsylvania, and at the borough of Warren a junction is effected with the Allegheny river. By general course the length of the stream is 45 or 50 miles. There are dams at various points along its course, but the chief manufacturing point within the section drained is Jamestown, a very attractive and enterprising village of between 9,000 and 10,000 inhabitants, about 3 miles from the foot of Chautauqua lake. The outlet of this lake runs easterly through the town of Ellicott, and having been joined by Cassadaga creek continues into the town of Poland, where it joins the Conewango.

Chautauqua lake lies near the center of the county bearing the same name, its head within 8 miles of lake Erie. It occupies a long and deep depression among the surrounding hills, which rise 600 or 800 feet above its level. The length of the lake is 16 or 18 miles; in width it varies, in general, from 1 to 2 miles, but near the center becomes so contracted as to receive the appearance of two separate lakes joined by a narrow arm. As represented on French's map of New York state, its surface covers an area of about 18.4 square miles, and in the *Gazetteer of New York* its elevation above tide is stated as 1,291 feet. Assuming the corresponding elevation at the mouth

of Conewango creek to be 1,190 feet,(a) there is a fall to that point from the lake of 101 feet in a distance, following the windings of the stream as accurately as practicable on the map, of about 34½ miles; the average descent for the entire distance is therefore not far from 3 feet to the mile.

The main employment of the outlet for water-power is at Jamestown, the manufactures of which are quite extensive in shoes, chairs, worsteds, cottons, alpacas, and other goods, but are largely based upon steam as motive power. The stream is there perhaps 50 feet wide, and in the upper part of the village is obstructed by a dam by means of which a partial control is exercised over the storage of the lake. There is a tributary area above that point, including the surface of the lake itself, of 178 square miles, but the restrictions are such that the drainage passing down through the outlet can not be maintained at a uniform rate of flow during the year, but at certain times there is a considerable wastage over the dam, and at others the supply of water runs short at the mills. Numerous springs assist in feeding the lake, and the rains and melting snows of spring regularly fill it and cause a surplus of water for the demands of the mills at Jamestown. From spring on through the dry season the volume is steadily reduced, the range in level during the year being stated as ordinarily 3 feet, or from 1 foot above the crest of the upper dam to 2 feet below. Occasionally a strong wind up the lake will almost entirely cut off the discharge through the outlet. The lake is navigable, and is thus largely utilized in summer, both by pleasure steamers and for the transportation of freight to and fro between Jamestown and Maysville, at the head, where connection is had with the Lake Shore and Michigan Southern railway by a short intervening line. Near the foot of the lake the depth is shallow, and the interests of navigation forbid the lowering of the water-surface to any considerable extent; and, on the other hand, it has been decided in court that the surface must not be artificially maintained at a higher level than under the present arrangement.

From the upper dam a race follows down the left bank of the outlet, giving at the lower mill a fall of about 11 feet, and supplying power to two grist-mills and to half a dozen or so other establishments, comprising in their production machine- and foundery-work, axes, washing-machines, planters, chairs, sashes, doors, blinds, and other articles. D. H. Grandin has a first right to sufficient water for use in his grist-mill, and estimates that about 125 horse-power of water-wheels is there employed under a fall of 11 feet. For about one-half the year the supply of water is equal to the requirements of the various mills on the race, but during the rest of the time, and especially in the months of July, August, and September, most of them are compelled to rely in large part upon steam. With all the other concerns shut down there is at times not enough water for the five wheels at Grandin's mill, and when there is an unfavorable wind on the lake there is even for a day or two at a time an insufficient amount for a single wheel.

In the lower part of the village the outlet is again dammed, and a fall of 6 feet is obtained, furnishing power to Allen, Preston & Co.'s woolen-mill, to John T. Wilson's saw-mill, lath-mill, and sash-and-blind factory, and to the Breed Furniture Company's works; some waste water is also used in a stave factory.

Still farther down in Jamestown, at a place locally known as Dexterville, another privilege is in use, with an extreme fall stated as 16 feet. About this point are grouped a grist-mill, a saw-mill, and works for the manufacture of axes and edge-tools.

Drainage areas.

	Square miles.
Chautauqua outlet at foot of lake	178
Chautauqua outlet below Cassadaga creek	343
Conewango creek at mouth	896

French creek.—Heading in the extreme southwestern corner of New York state, in Chautauqua county, its sources within a dozen miles of lake Erie, French creek, or, as it was once called, the Venango river, enters Pennsylvania, and making a bold curve to the westward through the counties of Erie and Crawford, swerves around to the southeast, cuts across a corner of Mercer, and near the center of Venango county joins the Allegheny. The area of its drainage basin has already been given as 1,130 square miles. Its entire length is by general course 75 miles, or, following the bends closely by map measurement, 90 miles; but portions of the stream are very crooked, and the actual distance by water from source to mouth is doubtless considerably greater.

The country drained has a moderately rolling surface, and was formerly covered with a heavy growth of timber, which was cut and rafted down the stream. The supply of pine has now become greatly reduced, and comparatively little rafting is done. For that which is still carried on advantage is taken of the high stages of water prevailing in spring, early summer, and fall. There is an important rise in the spring, largely due to melting snows, and another in June, caused by heavy rains; after the latter freshet no rafting is done until the water is again raised by autumn rains. Many years ago the stream was very gradual in its fluctuations, rising slowly and remaining up for a long time. Within the course of fifty years, however, there has been a noticeable change in this respect, and with the clearing of the country the oscillations have come to take place more rapidly, though even now the stream appears by no means to be what may be termed "flashy". At the mouth it is stated that after a general rain the stream continues rising for about twenty-four hours beyond the cessation of the storm. The bed is in general gravelly, though at the mouth composed of a soft rock which slakes on exposure to the air. The banks are much of the way

a See elevation at Warren, table showing the fall in the Allegheny river, page 10.

of black loam, and though of fair height are often unequal, being on the one hand low and succeeded by flats, while on the other they rise to bluffs. They are not so high but that in many localities they are submerged during extreme freshets, and in some places during ordinary ones. The common spring rise at Meadville is stated to be in the neighborhood of 11 feet, but at times the stream has been known to run a mile wide, stretching from hill to hill. Springs are said to be freely scattered over the drainage basin, and the low-water volume of the stream is fairly well sustained. West of Meadville there is a lake of considerable size, and also in the upper waters there are one or two small tributary lakes.

Table showing the fall in French creek.

Locality.	Distance from mouth.	Elevation of water-surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Miles. (a)	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Crossing of New York, Pennsylvania, and Ohio railroad a short distance east of Cambridge.	42.7	1,128	70	20.0	3.5	Elevations kindly furnished by Mr. Charles Latimer, chief engineer of the New York, Pennsylvania, and Ohio railroad.
Crossing by above railroad a few miles below Meadville.	22.7	1,058	80	22.7	3.5	
Mouth of creek	0.0	978				See table of fall in Allegheny river.

a By map measurement.

The section tributary to French creek is finely suited to farming, and has a large production of wheat, wool, butter, and cheese, and many cattle are raised. Although most of the pine timber has been cut, much hard wood yet remains standing in the upper basin. In the region about Meadville the soil on the hills is clayey, while in the valleys there is a rich black loam. Toward the mouth the land is described as finely adapted to wheat-raising, but poorly farmed; the production of wheat is thought to be steadily increasing, however, throughout this part of the state. On the main portion of the stream the principal places are Franklin, directly at the mouth, with a population of 5,000; and Meadville, some 30 miles above, with 8,900. In addition to the use of the stream for floating rafts, there is a small amount of navigation by flat-boats, these and the rafts passing down over the dams in long sloping chutes, from which water is at other times excluded by a log placed across at the head. Years ago Meadville enjoyed communication, via the Erie canal of Pennsylvania, both with the Ohio river at Beaver and with lake Erie at Erie. From a point 2 miles above the city, a canal opened out from French creek, and following down through and for about 7 miles below Meadville on the east bank, then crossed the stream on an aqueduct, and passing westwardly along the valley of Conneaut outlet reached Conneaut lake, on the summit between French creek and the Beaver river. This lake, which when full covered 2,600 acres, was artificially raised by an embankment and served as a storage reservoir, feeding the main canal both northerly down the Conneaut Creek valley toward lake Erie, for 45½ miles, and southerly for 15½ miles down the Shenango line toward the Ohio river. The canal was long since abandoned, but the lake of course remains as such, though it is thought to be lower than it was when in use for storage. It lies in a marshy district which is being successfully drained. The greater portion of French creek is followed closely by the New York, Pennsylvania, and Ohio railroad—below Meadville by its Franklin branch, and above by the main line.

Measurements of the volume of water flowing in this stream were made once or twice previously to 1839, also during that year, and again in 1867, the results of each being recorded in a report made in December, 1867, by the late W. Milnor Roberts, at that time consulting engineer to the Erie Canal Company of Pennsylvania. These measurements were made in the vicinity of Meadville, and in October, 1878, a rough gauging was made at the mouth of the stream by Mr. Thomas P. Roberts, then engaged in a reconnaissance of the Allegheny. The volumes of flow found by these various gaugings, together with some additional data, are contained in the following table:

Data concerning the flow of French creek.

Locality of gauging.	Date of gauging.	Stage of water.	Drainage area.	Flow per second.	Flow per second per square mile.	Remarks.
			Square miles.	*Cubic feet.*	*Cubic feet.*	
Above Meadville (*a*)	Previously to 1839.	Stated as minimum flow of extreme low water.	618	138	0.22	Gauging by Alonzo Livermore, civil engineer.
Do	do	do	618	159	0.26	Gauging at another time by Major Douglass, civil engineer.
Site of feeder-dam, 2 miles above Meadville.	September, 1839	Unusually low, but not extreme low water.	618	380	0.61	Gauging under direction of W. Milnor Roberts.
Do	October, 1867	Minimum flow at driest part of an unusually dry season.	618	222	0.36	Gauging made by H. H. Loveridge, under direction of W. Milnor Roberts.
Mouth of stream	October, 1878	Not stated, but the Allegheny was about 5 inches above its lowest stage, and during the month its principal tributaries were found very low.	1,130	708	0.63	Rough gauging made by Thomas P. Roberts, United States assistant engineer.

a Assumed to have been at feeder-dam, though not definitely so stated.

French creek was not examined above Meadville. There is said to be a paper-mill run by water-power 4 miles above the city, a flouring-mill at Saegerstown, another at Venango, and probably more or less use of power at other points farther up the course. At Meadville the stream runs about 175 feet wide, and on the right or west side approaches close to the high hills which inclose the valley; on the east side is a broad level plateau, on which the city lies, and beyond a rise to hills. The power of the stream is here put to use for the city water-works, and for a flouring-mill carrying 5 runs of stones and some rollers. Advantage has been taken of the old state improvements, water being brought some 2 miles from the feeder-dam in the channel of the canal which has already been mentioned. The total fall which could be obtained with the present height of dam and length of canal is stated as 21 feet; the fall actually in use ranges from 16 to 18 feet. The water-works have a single wheel, rated at about 110 horse-power, and the flouring-mill has 2 wheels, also estimated to give in the aggreate a little over 100 horse-power, but at neither place is the full power commonly in use. The supply of water is always sufficient for the water-works alone, but in low water sometimes will not fill the demands of both these and the flouring-mill. The dam is some 400 feet long, with an entire width at base of 90 or 100 feet. Many years ago there was a dam at this site, but the overfalling water scoured a deep hole below it and the state built a new structure immediately below, filling the intervening space with stone. The present dam, or at least the newer portion, is a timber and stone crib-work covered with a double thickness of 4-inch planking. The fall from water-surface to water-surface is commonly about 10 feet, but in places the dam itself is thought to have a height, measured between foundation and crest, of as much as 25 feet.

Estimate of power at Meadville.

Stage of water.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power (rated) of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 *foot fall.*	17 *feet fall.*	21 *feet fall.*	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*				
Low water, dry year	10	14½	9½	9	43	*a* 618	120	13.63	230	290	210±
Low water, average year							160	18.18	310	380	
Available 10 months, average year							240	27.26	460	570	

a At feeder-dam; drainage area at city, below Cussewago creek, is 720 square miles.

From Meadville to Franklin there was no power in use, so far as could be learned. In that distance there is a good current, with occasional ripples, and one or two considerable rapids, as at Carleton and near Franklin. For the whole section the average fall is probably not over 3 feet per mile. The valley is narrow, apparently seldom much exceeding a quarter of a mile in width between the bases of the hills, these growing higher and more abrupt toward the mouth of the stream. The course of the latter usually borders the hills on one side, but the opposite bank is low, and herein seems to lie, aside from the moderate fall, the principal objection to the development of power on this portion of the stream. There are doubtless some points where the banks would admit of a dam of fair height, but in general it may be said that any material raising of the water-surface would aggravate overflows above and endanger the railroad track, which, it is said, is even now sometimes submerged at points.

The last mill on the stream is at Franklin, but a short distance from the mouth. French creek has in this portion of its course a width ranging from 200 to 350 feet. In the valley-sides are outcropping horizontal strata of rock, which farther to the northward are not much exposed. Franklin is on the west bank, on a rather narrow plateau. Directly opposite, across French creek, there rises steeply a hill honeycombed with oil-wells and covered with a forest of derricks. Here, as at Meadville, the water-privilege has the benefit of an old state dam, built, in this case, some twenty-five or thirty years ago for the purpose of creating slack-water navigation. It is 325 feet long, and gives a fall of about 5½ feet; the construction is of timber and stone crib-work. The Venango flouring-mill, of which Messrs. Johnson & Co. are proprietors, carries 12 sets of rollers, and has a capacity for 100 or 125 barrels of flour per day. Six water-wheels are in use, estimated at 100 horse-power in the aggregate. Considerable leakage takes place through the dam; and for as much as one month in an ordinary year, and even two months in an unusually dry one, the mill has not a full supply of water. Freshet backwater from the Allegheny now and then causes a stoppage for a day or two, and ten years or so ago an ice-gorge a mile below in that river raised the water-surface in French creek above the crest of the dam, and for a month the mill could not be run.

Estimate of power at Franklin.

Stage of water.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power (rated) of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 *foot fall.*	5½ *feet fall.*	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year	10	13½	10	9½	43	1,130	210	23.86	130	100
Low water, average year							280	31.81	170	
Available 10 months, average year							420	47.71	260	

Coal can, of course, conveniently and cheaply be obtained in this section. At Franklin the cost of "slack" coal (fine refuse from the mines, much used as fuel in generating steam) was stated to range ordinarily between $1 25 and $1 40 per ton, delivered, while it sometimes has reached as low figures as $10 or $12 per car-load. The price of coarse coal, by the car-load, was given as $2 50 per ton, delivered (December, 1882). Yet, notwithstanding the cheapness of fuel, the proprietors of the Venango mill were confident that, considering the cost of engineer and fireman, of coal, oil, insurance, and other items, they secured a more economical power from the river than they could from steam.

Table of utilized power on the Allegheny river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Allegheny river	Ohio river	Pennsylvania	Potter	Flouring and grist	2	18	52	.....	
Do	do	do	do	Saw	4	30	120	.....	
Do	do	do	McKean	do	2	6+	119	.....	
Do	do	do	do	Flouring and grist	1	7	30	.....	
Do	do	New York	Cattaraugus	Saw	2	11	350	.....	Town of Portville.
Do	do	do	do	Saw and pulp	1	8	200±	.....	Salamanca.
Do	do	Pennsylvania	Warren	Saw	4				
Do	do	do	do	Paper and pulp	1				
Do	do	do	do	Shingle	1	6	350±	.....	Corydon privilege.
Do	do	do	do	Wooden handles	1				
Oswayo creek and tributaries.	Allegheny river	do	Potter	Flouring and grist	4	21+	75	.....	
Do	do	do	do	Saw	9	58	260	.....	
Do	do	do	McKean	do	2	13	120	.....	
Do	do	New York	Allegany	do	1	6	30	.....	
Do	do	do	do	Flouring and grist	1	17	30	15	
Conewango creek	do	do	Chautauqua	Bee-hives	1		20	.....	
Do	do	do	do	Lumber, planed	1	10	20	.....	Poland.
Do	do	do	do	Flouring and grist	1		100	.....	
Do	do	do	do	Saw	1		40	.....	
Do	do	do	do	do	2	14	50	.....	
Do	do	do	do	Flouring and grist	2	15	43	.....	
Do	do	do	Cattaraugus	Saw	1	11	12	.....	
Do	do	Pennsylvania	Warren	Flouring and grist	1		40	.....	
Do	do	do	do	Furniture	1		6	.....	
Do	do	do	do	Patent medicines and compounds.	1	6	5	5	Warrenborough.
Do	do	do	do	Sashes, doors, and blinds	1		22	.....	
Do	do	do	do	Wheelwrighting	1		5	.....	
Do	do	do	do	Flouring and grist	1	6	20	.....	
Do	do	do	do	Saw	1	10	25	.....	
Do	do	do	do	Woolen	1	5	10	.....	
Cassadaga creek and sundry small tributaries.	Conewango creek	New York	Chautauqua	Flouring and grist	5	54½	125	30	
Do	do	do	do	Saw	2	13	55	.....	
Do	do	do	do	Butter and cheese	1	6	2	.....	
Chautauqua outlet	Cassadaga creek	do	do	Axes	1	Jamestown and vicinity—total fall at three privileges, about 33 feet.	.....	.....	
Do	do	do	do	Carpentering	1		15	.....	
Do	do	do	do	Cooperage	2		77	.....	
Do	do	do	do	Cutlery and edge-tools	1		175	80	
Do	do	do	do	Flouring and grist	5		398	30	
Do	do	do	do	Furniture	3		53	20	
Do	do	do	do	Lumber, planed	1		50	.....	
Do	do	do	do	Machinery	3		65	.....	
Do	do	do	do	Sashes, doors, and blinds	2		15+	.....	
Do	do	do	do	Saw	5		237	200	
Do	do	do	do	Staves	1		.....	.....	
Do	do	do	do	Wheelbarrows	1		45	.....	
Do	do	do	do	Washing-machines and clothes-wringers.	1		5	.....	
Do	do	do	do	Woolen	1		20	.....	
Sundry tributaries	Chautauqua lake	do	do	Flouring and grist	5	60	153	105	
Do	do	do	do	Saw	4	75	40	.....	
Do	Conewango creek	do	do	do	9	136½	168	45	
Do	do	do	do	Flouring and grist	3	45	106	15	
Do	do	do	Cattaraugus	do	1	18	20	.....	
Do	do	do	do	Saw	3	57	60	.....	
Do	do	do	do	Tannery	1	11	18	20	

Table of utilized power on the Allegheny river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Sundry tributaries	Conewango creek	Pennsylvania	Warren	Saw	1	22	20	.....	
Kinzua creek	Allegheny river	do	McKean	Saw	3	19	46	.....	
Do	do	do	Warren	Flouring and grist	1	7	15	.....	
Broken Straw creek	do	New York	Chautauqua	Agricultural implements	1	9	22	.....	
Do	do	do	do	Flouring and grist	3	34	142	.....	
Do	do	do	do	Saw	1	9	10	.....	
Do	do	Pennsylvania	Erie	Woolen	1	6	16	.....	
Do	do	do	Warren	do	1	7	35	.....	
Do	do	do	do	Wheelwrighting	1	11	8	.....	
Do	do	do	do	Saw	7	61	173	.....	
Do	do	do	do	Flouring and grist	4	27	108	.....	
Tributaries	Broken Straw creek.	do	do	do	1	7	20	.....	
Do	do	do	do	Saw	3	20	60	40	
Tionesta creek	Allegheny river	do	Forest	do	3	28½	165	.....	
Do	do	do	do	Flouring and grist	1	12	60	.....	
Do	do	do	Warren	Saw	2	15	24	.....	
Do	do	do	do	Tannery	1	.....	12	.....	
Tributary	Tionesta creek	do	Forest	Saw	1	30	60	50	
Oil creek	Allegheny river	do	Crawford	Flouring and grist	4	35	223	.....	
Do	do	do	do	Saw	7	82½	107	.....	
Do	do	do	do	Wooden handles	1	5	23	.....	
Tributaries	Oil creek	do	do	Flouring and grist	1	10	38	30	
Do	do	do	do	Saw	3	25	85	.....	
Do	do	do	do	Woolen	1	8	15	.....	
Do	do	do	Venango	Flouring and grist	1	16	25	.....	
French creek	Allegheny river	New York	Chautauqua	do	2	20	56	15	
Do	do	do	do	Saw	2	15	37	.....	
Do	do	Pennsylvania	Erie	Flouring and grist	4	35	102	.....	
Do	do	do	do	Saw	8	89½	180	25	
Do	do	do	do	Sashes, doors, and blinds	1	7	6	.....	
Do	do	do	Crawford	Flouring and grist	3	27	242	.....	
Do	do	do	do	do	1	18½	100	.....	Meadville.
Do	do	do	do	Pumping-works	1		110	.....	
Do	do	do	do	Paper	1	.....	.....	.....	
Do	do	do	do	Saw	1	5½	6	.....	
Do	do	do	do	Woolen	1	5	20	.....	
Do	do	do	Venango	Flouring and grist	1	5½	100	.....	Franklin.
Tributaries	French creek	New York	Chautauqua	do	1	10½	27	.....	
Do	do	Pennsylvania	Erie	Cooperage	1	9	18	.....	
Do	do	do	do	Flouring and grist	2	18	70	25	
Do	do	do	do	Furniture	1	6½	8	.....	
Do	do	do	do	Machinery	1	9	9	.....	
Do	do	do	do	Saw	7	70+	148	30	
Do	do	do	do	Tannery	1	6	10	.....	
Do	do	do	do	Wooden handles	1	10	31	.....	
Do	do	do	Crawford	Flouring and grist	16	199	582	265	
Do	do	do	do	Iron castings	2	12	40	61	
Do	do	do	do	Saw	21	170½	407	35	
Do	do	do	do	Tanneries	2	23	20	.....	
Do	do	do	do	Woolen	1	8	20	.....	
Do	do	do	Mercer	Flouring and grist	1	20	20	.....	
Do	do	do	Venango	do	5	61	125	.....	
Do	do	do	do	Saw	2	10	35	.....	
Do	do	do	do	Wheelwrighting	1	11	8	.....	
Do	do	do	do	Woolen	1	16	6	.....	
Clarion river	Allegheny river	do	Elk	Saw	4	38½	305	.....	
Do	do	do	Jefferson	do	2	30	40	80	
Do	do	do	Forest	Saw	2	28	110	60	
Do	do	do	Clarion	do	4	57	110	40	
Do	do	do	do	Flouring and grist	2	6	38	.....	
Tributaries	Clarion river	do	Elk	Saw	11	156	293	.....	
Do	do	do	Jefferson	do	6	72	145	.....	
Do	do	do	do	Flouring and grist	1	7	12	.....	
Do	do	do	Forest	do	1	16	15	.....	
Do	do	do	Clarion	do	21	335	516	47	
Do	do	do	do	Saw	7	78½+	116	45	

Table of utilized power on the Allegheny river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Tributaries	Clarion river	Pennsylvania	Clarion	Woolen	1	17	20		
Red Bank creek	Allegheny river	do	Jefferson	Flouring and grist	5	41	127		
Do	do	do	do	Saw	2	11½	62		
Do	do	do	Clarion	Flouring and grist	3	31	155		
Do	do	do	Armstrong	do	1	9	25		
Tributaries	Red Bank creek	do	Jefferson	do	6	77	152	100	
Do	do	do	do	Saw	11	110	297		
Do	do	do	do	Woolen	1	6	18		
Do	do	do	Clearfield	Flouring and grist	1	52	20	45	
Do	do	do	do	Saw	2	30	95		
Do	do	do	Clarion	Flouring and grist	2	22	30		
Mahoning river	Allegheny river	do	Indiana	do	7	49	285		
Do	do	do	do	Saw	1	11	50		
Do	do	do	Jefferson	do	3	23	150	52	
Do	do	do	do	Flouring and grist	7	60	208	20	
Do	do	do	Armstrong	do	3	17½	114		
Do	do	do	do	Saw	3	25½	120		
Tributaries	Mahoning river	do	do	do	1	15	20		
Do	do	do	do	Flouring and grist	1	24	15		
Do	do	do	Jefferson	Furniture	1	10	15		
Do	do	do	do	Saw	2	18	50		
Do	do	do	Indiana	do	4	27+	95		
Do	do	do	do	Flouring and grist	2	20½	75		
Do	do	do	Clearfield	do	1	30	20	35	
Do	do	do	do	Saw	5	107	135	30	
Kiskiminetas river	Allegheny river	do	Westmoreland	Flouring and grist	1	5	40		
Conemaugh river	Kiskiminetas river	do	do	do	2	28	28		
Do	do	do	do	Saw	1	10	6		
Do	do	do	Indiana	Flouring and grist	1	5	20		
Do	do	do	Cambria	do	4	39	60		
Do	do	do	do	Saw	7	91	130		
Small tributary	do	do	Westmoreland	Flouring and grist	1	14	15	25	
Loyalhanna creek and tributaries.	Conemaugh river	do	do	do	16	176	384	78	
Do	do	do	do	Woolen	1	15	10		
Other tributaries	do	do	do	do	5	65	60		
Do	do	do	do	Flouring and grist	5	99	105		
Do	do	do	Cambria	do	8	123	193		
Do	do	do	do	Saw	22	303+	404		
Do	do	do	do	Tannery	1	6	12		
Do	do	do	do	Woolen	1		15	40	
Do	do	do	Indiana	Flouring and grist	14	199½	357	55	
Do	do	do	do	Furniture	1	10	12		
Do	do	do	do	Saw	22	265+	456		
Do	do	do	do	Woolen	3	36	39		
Do	do	do	Somerset	Flouring and grist	23	338	455	84	
Do	do	do	do	Furniture	1	22	8		
Do	do	do	do	Saw	36	386+	651	30	
Do	do	do	do	Tannery	1	8	3		
Do	do	do	do	Woolen	2	20	24		
Sundry small streams	Allegheny river	do	Potter	Flouring and grist	1	24	48		
Do	do	do	do	Saw	1	20	30		
Do	do	do	McKean	Flouring and grist	2	12	50		
Do	do	do	do	High explosives	1	9	1		
Do	do	do	do	Sashes, doors, and blinds	1	4	12		
Do	do	do	do	Saw	6	114	218	65	
Do	do	New York	Allegany	do	2	52	65		
Do	do	do	do	Flouring and grist	2	28	40	20	
Do	do	do	Cattaraugus	Carriage and wagon materials.	1	17	16		
Do	do	do	do	Cooperage	1	18	15		
Do	do	do	do	Flouring and grist	9	109	310		
Do	do	do	do	Saw	20	335½	848	135	
Do	do	do	do	Woolen	1	7	10		
Do	do	do	Warren	Saw	9	104+	214	60	
Do	do	do	Forest	do	3	30	135		
Do	do	do	do	Flouring and grist	2	33	46		

Table of utilized power on the Allegheny river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Sundry small streams	Allegheny river ..	New York	Erie	Knitting.....	1	.....	20	.....	
Do.....	....do	....do	....do	Cloth rolls and yarns	1	6	15	.....	
Do.....	....do	....do	....do	Saw	2	14	27	.....	
Do.....	....do	....do	Mercer	Flouring and grist.....	2	27	40	.....	
Do.....	....do	....do	....do	Woolen	2	19+	26	.....	
Do	....do	... do	Venango.....	Blacksmithing.....	1	.....	12	.....	
Do.....	....do	....do	....do	Flouring and grist.....	10	92+	147	.....	
Do.....	....do	...do	....do	Woolen.....	1	9	.....	.....	
Do.....	....do	....do	Clarion	Flouring and grist.....	3	52½	106	60	
Do.....	....do	....do	....do	Saw	1	11	10	.....	
Do.....	....do	....do	Butler	Flouring and grist.....	6	91	145	125	
Do.....	....do	Pennsylvania ...	Armstrong ...	....do	18	277	410	309	
Do.....	....do	....do	....do	Saw	3	34	55	.....	
Do.....	....do	....do	....do	Woolen.....	1	9	10	.....	
Do.....	....do	....do	Indiana.....	Flouring and grist.....	6	66	119	108	
Do.....	....do	....do	....do	Saw	3	.....	18	.....	
Do.....	....do	....do	Westmoreland	Flouring and grist.....	2	20	38	38	
Do.....	....do	....do	Allegheny	....do	7	10½	151	120	

THE MONONGAHELA RIVER.

The main river is formed in Marion county, in the northern part of West Virginia, by the union of its West fork with the Tygart's Valley river. It then pursues a winding course to the northward for over 120 miles, entering Pennsylvania and joining the Allegheny river at Pittsburgh to make up the Ohio. The drainage basin comprises 7,625 square miles, against 11,107 for the Allegheny, and lies principally in the states already mentioned, though including also a small adjacent section of Maryland. The Monongahela drains part of the western slope of the Alleghany mountains, and the eastern portion of its basin, especially about the upper waters of the Cheat river, is extremely rugged, with little fertility. Passing to the westward across West Virginia, the country in time loses its strictly mountainous appearance, and though it continues elevated, presents extensive table-lands, not necessarily level, but, on the other hand, only moderately hilly and with rounded slopes. All this region was once heavily timbered, but has been quite thoroughly cleared except about the upper waters of the principal streams. Poplar is found well distributed; there is also much oak along the upper course of the West fork, and it is said that in the district tributary to the Cheat river there is considerable wild cherry, as well as spruce and hemlock. This upper portion of West Virginia is a blue-grass region, and is therefore splendidly suited to grazing. It yields largely in corn, but cattle-raising is the principal industry. Very little iron ore is found in the upper basin of the Monongahela, so far as ascertained, except toward its eastern border, but the variety of coal known as "Pittsburgh" occurs over the greater part, and in the vicinity of Fairmount, near the head of the main river, lies in four seams, of 11 feet, 5 feet, and two of 4 feet thickness, respectively.

Descending from the junction of the West fork with the Tygart's Valley river, the first use of water-power is found at Fairmount, an important village 3 miles below located on high bluffs on the left bank of the river. The latter is here crossed by a fine suspension bridge, and immediately under this is a low dam, not more than 4½ feet high, extending boldly up stream from each shore, and made up of four straight sections. The river-bed in this vicinity is mainly composed of sandstone ledge rock, coal-seams also occurring at points, and is covered more or less with gravel, and finer material in the pools. The dam is a crib-work of the following construction: Two sills cross the stream, resting on the bed; on the down-stream sill the face of the dam is carried up in say four courses of timbers, each course secured by binders—saplings of less diameter—running to the up-stream sill and firmly dovetailed to it. The face-timbers break joints, and the binders do not come one above another, but are distributed irregularly. The whole structure is thoroughly bolted together, and all interstices are closely packed with loose rock. A fall of 4 or 4½ feet is obtained, and is utilized on the right bank at Springer & Barnes' 2-run flouring-mill. On the opposite bank there is also a small mill, not regularly run. Springer & Barnes count upon about eight months of good grinding at their mill during the year. The dam is not tight, and for two months or so in summer the mill is short of water, while for an equal length of time in winter the high stage of river prevents running on account of the backwater. The stream is about 450 feet wide at Fairmount, and is subject to great oscillations, having been known to rise, in extreme cases, 35 or 40 feet above the low-water surface below the dam.

Table showing the fall in the Monongahela river and its principal tributaries.

Stream and locality.	Distance from mouth. (a)	Elevation of low-water surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Cheat river at Baltimore and Ohio Railroad crossing, Rowlsburg, West Virginia.	39	1,320	546	39	14.0	Baltimore and Ohio Railroad levels.
Cheat river at mouth	0	774				Estimated by adding to elevation at Pittsburgh 74½ feet, ascent to Virginia line, as determined by old survey. Now possibly altered somewhat by slack-water dams.
Tygart's Valley river at Baltimore and Ohio Railroad crossing, Grafton, West Virginia.	18	952	114	18	6.3	Baltimore and Ohio Railroad levels.
Tygart's Valley river at mouth	0	838				Do.
West fork of Monongahela river at Baltimore and Ohio Railroad crossing, Clarksburg, West Virginia.	25	890	52	25	2.1	Do.
West fork of Monongahela river at mouth	0	838				Do.
Youghiogheny river at Baltimore and Ohio Railroad crossing near Oakland, Maryland.	95	2,323	1,606	95	16.9	Do.
Youghiogheny river at Baltimore and Ohio Railroad crossing near Connellsville, Pennsylvania.	41	*b* 890				Do.
Youghiogheny river at mouth	0	717				Elevation roughly estimated.
Monongahela river at Baltimore and Ohio Railroad crossing 2 miles above Fairmount, West Virginia.	123	898	130	123	1.1	Baltimore and Ohio Railroad levels.
Monongahela river at mouth	0	699				Low water in Ohio river at Pittsburgh 699.2 feet above mean sea-level (see *Elevations of Datum Points*, by James T. Gardner, United States Geological Survey).

a Obtained by map measurement, and to be considered as approximate only. *b* Elevation of rails.

NOTE.—Elevations at points on the lines of the Baltimore and Ohio railroad were furnished through the kindness of Mr. James L. Randolph, consulting engineer of the company.

From Fairmount down to Morgantown, a distance of between 20 and 25 miles, the fall in the river is said to average slightly over a foot to the mile. The "Big falls" and "Little falls" indicated upon maps as occurring in this section, are described as not of any importance as regards amount of descent; at the former there is in low water an abrupt pitch of a foot or two, while the "Little falls" consist of rapids located in a sharp bend of the stream. Power is used at three points between Fairmount and Morgantown by small grist-mills obtaining their fall from low dams rudely built of loose stones.

Below Morgantown the river is not utilized for water-power in manufacturing at any point, with the single exception of the dam at Port Perry, near McKeesport, where there is a saw-mill turning out about 1,000,000 feet of lumber annually and employing 70 horse-power of wheels. In one sense navigation may be said to extend up the river to Fairmount, inasmuch as during high water steamers have occasionally ascended to that place. But the only regular navigation extends, or will soon extend, to Morgantown, 102 miles above the mouth, and is made possible by a series of dams creating slack-water. The first suggestion of an improvement of the navigation of the Monongahela by locks and dams is said to have been made in the report of a survey undertaken for the state by E. F. Gay, civil engineer, in 1828. Congress having declined the improvement of the river, by act of the state assembly of Pennsylvania, of March 31, 1836, "The Monongahela Navigation Company" was authorized to create slack-water navigation to the Virginia line and as much farther as the latter state might permit it to go. A survey was made in the summer of 1838 under W. Milnor Roberts, with the following results: From Pittsburgh to Brownsville the distance was found to be about 55½ miles, and the ascent a little over 33½ feet; from Brownsville to the Virginia line a little over 35 miles, with an ascent of 41 feet. The company constructed six dams, giving navigation to Jacob's creek, 84 miles from Pittsburgh. At a point above, known as Hoard's rocks, there was completed by the United States government, during the fiscal year ending June 30, 1880, a lock and dam creating slack-water to Morgantown. Two more dams were necessary in order to connect this navigation with that of the lower river—one at Jacob's creek, and a second between there and Hoard's rocks, at Laurel run. In 1880 Congress appropriated $25,000, and an equal amount in 1881, toward the necessary work at Laurel run, the second appropriation being on the condition that the navigation company should give proper assurance that it would construct the lock and dam at Jacob's creek. This assurance was given, and whenever the work shall have been finished there will be continuous navigation from Pittsburgh to Morgantown.

From Pittsburgh to McKeesport, some 15 miles, the Monongahela is lined at short intervals by extensive iron furnaces and mills. It runs through this section in a narrow valley, bluffs rising high on either side with varying abruptness. At some points there seems to be scarcely more than sufficient room left for the railroad which follows the east bank, while again the hills slope more gently, or recede from the water, leaving stretches perhaps a quarter of a mile wide of flat alluvial land which is under cultivation. Between the cities mentioned the navigation company has two of its dams, the rest being farther up the river. During much of the year there must evidently be a large

available power at these various dams, but the company has all the business in connection with navigation that it can attend to and does not wish to dispose of any water-power. None is now used except in operating the lock-gates, and, as we have seen, by a single saw-mill at Port Perry.

In view of the uncommonly dangerous character of this river as regards freshets and ice-runs, it may be of value to give a brief account of the navigation company's dams. They are numbered in order ascending from Pittsburgh, and have been thus described: (*a*)

The dams are constructed of logs, squaring at least a foot, built up perpendicularly from the bed of the river to near the water-level, when they begin to slope on both sides to the comb, after the manner of an old-time log cabin. They are tied together by cross-timbers parallel with the line of the river, bolted to the longitudinal timbers so as to form a network, with interstices of 7 by 9 feet, filled with stone. Their breadth at the base is about 65 feet; their depth below the slopes, as originally built, is from 3 to 6 feet, though, by reason of breaches, they are now much deeper in places.(*b*) Dams 1 and 2 run straight across the river. No. 3 is in three straight lines of unequal length—the middle one 280 feet, the other two aggregating about 420 feet—the middle one being at right angles with the channel, the others sloping from it downward to the shores, about 22 feet from the line of the middle part. Dam No. 4 is a segment of a circle—about 605 feet in length—and curves up stream, having a versed sine of 15 feet. Dams 5 and 6 are also segments of a circle, with the convex sides up stream, and are each about 600 feet long. These, by reason of their increased height, 13½ and 14 feet, have the longest slopes on the lower sides. The others slope about equally above and below—from 3 to 4 feet of slope to 1 foot of rise. They are sheeted above with double courses of oak plank, closely laid, 5 inches thick, spiked to the timbers, and covered with gravel. The sheeting below is of heavy oak timbers, or spars, flattened to 8 inches and spiked to the crib-timbers. The dams are further secured at their ends by high, strong cribs filled with stone, and above by double courses of heavy sheet-piles driven vertically into the bed of the river to such depth as to secure anchorage to the entire structure. In some cases, since their original construction, piles have been driven in below vertically, and above slopingly.

In spite of the strength of the dams on the Monongahela they have frequently suffered during the heavy freshets which sweep down the river. In 1843, dam No. 1 was badly injured; in April, 1852, there were two freshets, of seven days' duration each, which entirely submerged the works and carried away the office-houses at dams Nos. 2 and 3, and severely injured the locks; in May, 1856, about 200 feet of dam No. 2 was swept out; and in May, 1858, there was a greater flood than that of 1852, but not attended by injury to the works. The freshets thus far mentioned were not accompanied by ice, or they might have proved still more destructive. In January, 1865, an ice-freshet, which at the same time tore out two dams on the Youghiogheny, made great havoc at dam No. 4; in 1867 there was a rise which carried out the heaviest ice of twenty years and did much harm to dams Nos. 2 and 6 and to the locks at Nos. 4 and 5; and in 1868 similar damage was caused at dam No. 2.

As described in the history already quoted from, written in 1873, the six dams met successively in ascending from Pittsburgh had for their respective heights 8, 8, 8, 10, 13½, and 14 feet. The heights are stated now to remain substantially the same, though they have been slightly increased on the lower river.

Drainage areas of the Monongahela river and principal tributaries.

Stream and locality.	Drainage area.	Stream and locality.	Drainage area.
	Sq. miles.		*Sq. miles.*
Castleman's river (tributary of Youghiogheny river)	481	Tygart's Valley river at Beverly	215
Youghiogheny river above Castleman's river	446	Tygart's Valley river at Philippi	835
Youghiogheny river below Castleman's river	927	Tygart's Valley river at Grafton (below Fork creek)	1,276
Youghiogheny river at Falls City (above Beaver creek)	1,071	Tygart's Valley river at Valley Falls	1,320
Youghiogheny river at Connellsville	1,334	Tygart's Valley river at mouth	1,367
Youghiogheny river at mouth	1,760	Monongahela river below junction of West fork and Tygart's Valley river.	2,355
West fork of Monongahela river at Weston	147	Monongahela river at Fairmount (above Buffalo creek)	2,367
West fork of Monongahela river at Milford	410	Monongahela river at Morgantown (below Decker's creek)	2,737
West fork of Monongahela river at Clarksburg (below Elk creek)	602	Monongahela river above Cheat river	2,805
West fork of Monongahela river at mouth (junction with Tygart's Valley river).	988	Monongahela river below Cheat river	4,364
Cheat river at Saint George	952	Monongahela river above Youghiogheny river	5,655
Cheat river at Rowlesburg (below Salt Lick creek)	1,000	Monongahela river below Youghiogheny river	7,421
Cheat river at mouth	1,550	Monongahela river at mouth	7,625

THE YOUGHIOGHENY RIVER.

As regards extent of drainage basin, this stream ranks first among the tributaries of the Monongahela, commanding, as it does, the flowage from between 1,700 and 1,800 square miles of territory. Its source is about 30 miles south of the Pennsylvania line, and close upon the boundary between the extreme western portion of Maryland and the adjoining county of Preston, West Virginia. The North branch of the Potomac rises but a few miles to the southward, on the opposite slope of Great Savage mountain. For 35 miles, by direct line, the course

a History of The Monongahela Navigation Company, by an original stockholder, 1873.

b "It required more stone (14,297 cubic yards) and timber to repair the great breach of May, 1868, in dam No. 2, than were used in its original construction, by reason of the washing out of the bed of the river, which is generally an incompact conglomerate of sand and rounded gravel. The breach of 1843 required to fill it, in the language of Mr. Lothrop, the engineer, 'an immense mass of timber and stone that no power can remove'. And generally, if not uniformly, such repairs have never had to be repeated."

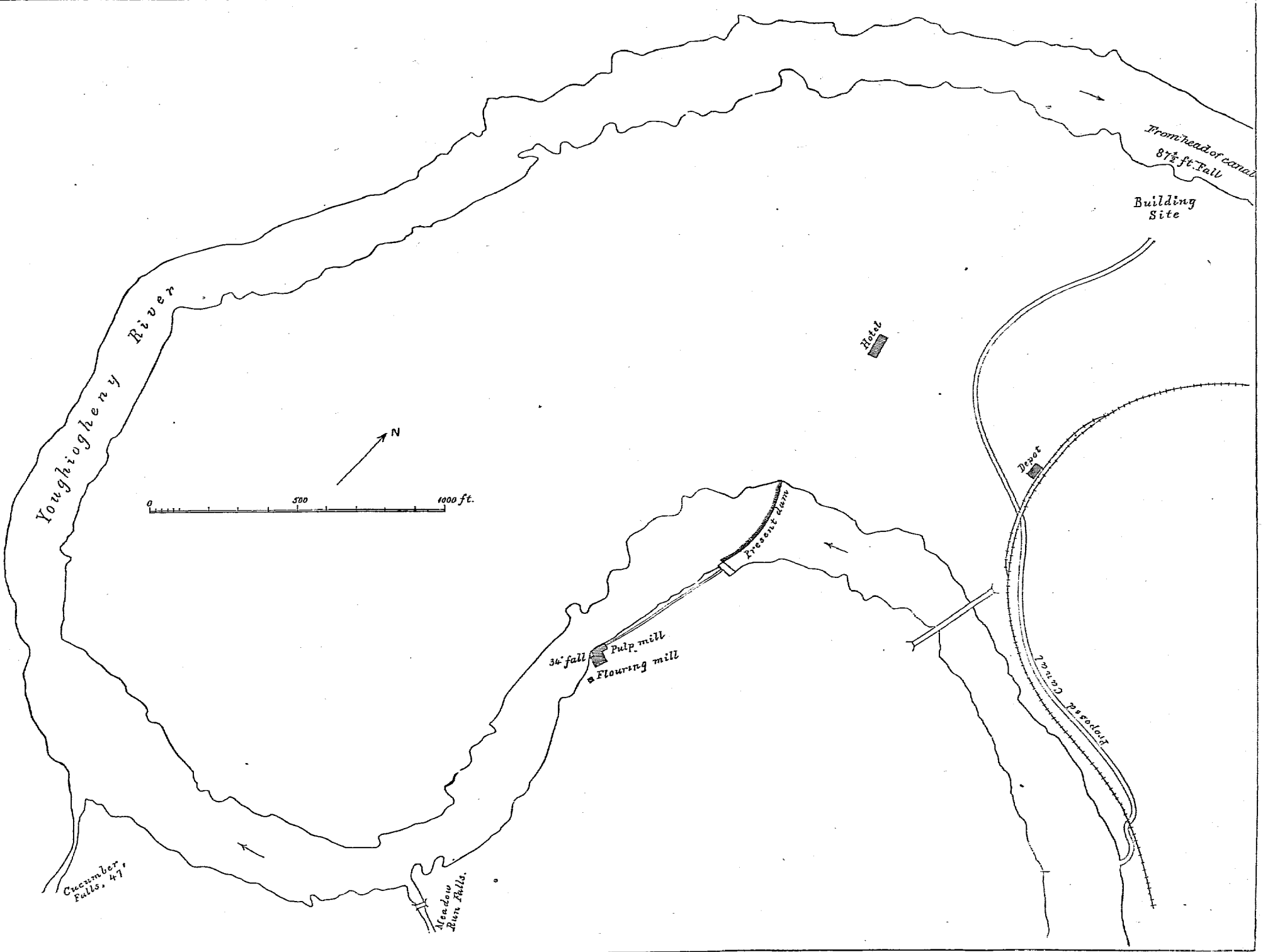
of the stream is almost due north, following the valley between Negro mountain on the east and the Briery mountains on the west. Six or 8 miles north of the Pennsylvania boundary the direction of flow changes to the northwest, carrying the river successively across Laurel hill and Laurel ridge, and on to its junction with the Monongahela, which is effected at McKeesport, some 15 miles above Pittsburgh. Measured by general course, the Youghiogheny has a length of about 85 miles. Much of the upper basin presents a very rugged surface and is well wooded. There is some rafting on the stream, but it is small in amount. Violent freshets occur, often aggravated by heavy runs of ice. At Connellsville it was stated that the common thickness of the ice, as it breaks up there at the close of winter, is about 12 inches; and that it seems to go out before the snow has melted very much in the mountains, not infrequently during a rather low stage of river, followed soon after by a rise from the mountains. In the middle of December, 1882, the river having fallen considerably within a few days, it was noticed by the author that in a narrow portion of the course a few miles below Connellsville ice was heaped up 5 or 6 feet high on either side near and upon the banks, and it was apparent that during the heavier breakings up at the end of the season the stream must often be an exceedingly difficult one to control. The principal freshet, with reference to the volume of water, is usually in June, and is caused by heavy rains; there is also a considerable rise in September. At such times much floating drift is brought down the stream. About the time when slack-water navigation was created on the Monongahela it was also extended up the Youghiogheny, by means of two dams and locks, as far as West Newton, 18 miles from the mouth, and much assistance was expected to the traffic on the main river. The expectation was not realized, however. The dams lasted but fourteen years, with long intervals of uselessness for want of repairs, and a great ice-flood in January, 1865, put an end to them. The charter of the company owning them is said to have since become extinct. It is stated that at present there is navigation for craft of 7 feet draught 4 miles above the mouth, and, except in extreme low water, 3 miles farther for those of not over 3 feet draught. Coal, coke, and other freight are brought by rail, and reshipped by water at the highest navigable point.

McKeesport, at the mouth of the river, is an important place of 8,000 inhabitants. Thence to Connellsville, about 40 miles, the Youghiogheny lies in a very narrow valley, shut in by high wooded hills. At times these rise abruptly from the water, and the railroad cuts reveal rocky strata; again they are less steep, and also leave a narrow strip of fertile land along the stream, cultivated for corn or other grain. The valley is in general too contracted to admit of extensive settlements. West Newton appears to be the principal place before reaching Connellsville, and has a population of 1,500; aside from this there are only small clusters of houses and the straggling, wretched-appearing quarters of the mining classes. The great industries of this valley are coal-mining and the burning of coke. Along the lower river the harder variety of bituminous coal is obtained, but in the vicinity of Connellsville a softer kind is mined and burned, or roasted, into coke, which is shipped away and extensively used in blast-furnaces. Long lines of the coke-ovens are to be seen near the river, while others stretch off among the hills, along short spur-lines of railroad. The Baltimore and Ohio railroad follows closely up the right or east bank, and in the winter of 1882–'83 a new line was being constructed on the opposite bank, designed, as it was said, to penetrate the coke region, and having for a northern connection the Pittsburgh and Lake Erie railroad. The only dam which was observed on this part of the river was at Port Royal, about half way between McKeesport and Connellsville; it was a low affair, with apparently but 1 or 2 feet of fall, and at one end was a distillery, where a small power might have been used. The width of the stream is quite irregular. Ripples appear now and then, where the depth is shallow and the current swift, and within a few miles of Connellsville there are one or two gravel shoals on which there is a moderate descent, but no rapids of any especial importance are encountered.

Estimate of power at Connellsville.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power (rated) of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	5 feet fall.	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year	10	12	0	8	30	1,334	120	13.6	70	50–100
Low water, average year							180	20.4	100	
Available 10 months, average year							300	34.1	170	

Connellsville is a borough of 3,600 inhabitants and is attractively located upon the river's bank. The hills which inclose the valley here recede from the stream, but at a distance they are to be seen rising, one ridge after another, high and thickly covered with timber. The river is at this point 250 or 300 feet wide, and is utilized to a small extent for power. A low wing-dam of logs and stone, with a facing of planks on the inshore side, extends some distance up stream parallel to the left bank and then out into the river. It is estimated to have cost at least $8,000, and diverts sufficient water so that, with the head of 5 feet gained by the fall in the river, power is furnished for operating steadily a small 2-run flouring-mill, the only interruption being an occasional stoppage of a day or two from high water. Ice causes more or less injury to the dam every year, and an average of perhaps $200 has to be spent in repairs. Opposite the head of the wing-dam a projecting point of land turns a portion of the flow of the



THE YOUGHIOGHENY RIVER AT OHIO PILE FALLS.

river to the right bank, where it is employed by a small flouring-mill and a planing-mill, but it is insufficient for their needs in low stages of water. Quite a heavy draught is said to be made upon the low-water volume of the stream, at a point a mile or so above, by a pump for supplying coke-ovens.

Ascending from Connellsville, the Youghiogheny soon assumes, and maintains to Falls City at least, 16 miles above, the characteristic features of a mountain stream. It is narrow and swift, almost a constant succession of ripples and rapids, many of them with heavy fall, and smooth water is exceptional.(*a*) Immense bowlders appear here and there in the stream and on the banks, and solid rock ledges are exposed at many points in the latter. High wooded hills rise on either hand, frequently with great abruptness from the water's edge, and never leaving a strip of meadow more than 100 or 200 feet wide. Indian creek enters from the east, and is the largest tributary in this section.

At Falls City, 56 miles by river above the mouth, occur the famous "Ohio Pile"(*b*) falls, where, by its rapid descent around a remarkable bend, the Youghiogheny offers a fine water-power, which is already partially utilized. In 1825 a commission, consisting of Colonel W. McKee, Colonel Roswell Lee, and Major George Talcott, was appointed by the United States government to select "a site for a national armory on the western waters", and it may be interesting to quote a portion of their report bearing upon the site at these falls:(*c*)

> The Youghiogheny river at this place makes a circuit of nearly 2 miles around a neck or tongue of land, about three-quarters of a mile in length, that projects from the foot of a mountain in its rear. At the upper side of this tongue, and near the extreme point of the mountain, is the commencement of the Ohio Pile rapids and falls, which terminate at the lower side opposite the point at which they begin, and 600 yards distant from it in a straight line. The whole descent is 87½ feet. The ground on the lower side, next the foot of the rapids, is advantageously disposed in steps or benches of sufficient width and at convenient distances below each other for the erection of buildings, and the successive application of the water to machinery in any manner that may be desired. Forty feet of the whole fall may thus be employed at a trifling expense. The bank then becomes steep and perpendicular, and the remaining part of the fall could not be conveniently used without extensive rock excavation. To convey the water to this site from above the falls will require a canal of 700 feet in length. The first 400 feet will pass through a strip of river bottom. The deepest cutting along the whole route is 30 feet, and occurs in passing a narrow ridge near the middle of the neck, consisting principally, as is supposed, of rock. A dam 4 feet high across the river will be necessary to procure a depth of water at the head of the canal sufficient to prevent it from being choked with ice, or obstructed by drift of any kind. The quantity of water which the river furnished at this place during an extremely dry season perhaps exceeded 100 cubic feet per second during the uncommon drought of 1823. If we regard the site of these falls, in reference to the security of the works that must be erected upon it from freshets, the perfect command of its water-power, and the cheapness with which it may be employed, it surpasses any that has ever come under our observation.

The river is here 150 or 200 feet wide. Within a few hundred feet it accomplishes a descent stated as 34 feet, and mainly included in abrupt pitches over masses of solid rock. In the banks are outcropping ledges of hard sandstone and conglomerate, and at points were noticed layers of sandstone inclined at a considerable angle and covered by horizontal strata. At the head of the falls a low dam crosses the river in a somewhat irregular line, arching well up stream; it is a log structure covered with planking, and is 400 feet in length, with the natural abutment afforded by a high rocky bank on the right, while at the opposite end is a timber and stone crib-work. From the latter point a flume conveys water perhaps 350 or 400 feet down the bank to W. W. Hartzell's wood-pulp mill, where a fall of something over 30 feet and 350 horse-power of wheels are in use; immediately adjoining, power is also employed in a 3-run flouring-mill with about the same fall. In some years there is throughout sufficient water for the full supply of these mills, and Mr. Hartzell was of opinion that if the whole flow of the river were utilized it would prove adequate in all ordinary years, but the dam is not tight and allows considerable waste, so that at times the power at the mills is curtailed.

Estimate of power at the Ohio Pile falls.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.				Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	34 feet fall.	40 feet fall.	87½ feet fall.	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*					
Low water, dry year	10	12	9	8	30	1,071	100	11.4	390	460	1,000	380
Low water, average year							150	17.0	580	680	1,490	
Available 10 months, average year							250	28.4	970	1,140	2,490	

Falls City is 74 miles from Pittsburgh, on the Pittsburgh division of the Baltimore and Ohio railroad, and is only a small village. The prevailing timber in the vicinity is hard wood, but spruce, poplar, and linn, all soft woods and suited to the manufacture of pulp, are also found in abundance. The water-privilege which has been described, together with a large tract of land in the vicinity, is said to be owned by the heirs of the late Andrew Stewart, of Washington, and to be under the control of Mr. D. S. Stewart, of that city, acting as attorney. The

a Between the crossing by the Baltimore and Ohio railroad near Oakland, Maryland, and that by its Fayette County branch near Connellsville, Pennsylvania, this stream has a fall of 1,458 feet, or an average for the whole distance of not far from 27 feet per mile.

b Supposed to be an Indian name signifying "beautiful falls".

c From *History of Fayette County.*

site is close by the railroad, and the full development of the fall would evidently furnish an important power. Mr. Hartzell holds part of the privilege, however, under lease, for the benefit of his pulp-works, and if water were diverted from above his dam across the neck of land in order to improve the entire fall, his rights would require to be purchased.

Above Falls City, up to Confluence, 8 or 10 miles beyond, the Youghiogheny appears rather less rough than below. There are still numerous rapids, but the fall is on the whole not so great, and there are some long stretches of comparatively smooth water. The valley, also, though very narrow in places, is yet generally more open than below Falls City. At Confluence the railroad branches off and follows up Castleman's river, which in point of drainage area is larger than the main stream above their junction. In general features the two streams are similar. The surrounding country, the flowage from which they receive, is very mountainous, with steep timbered slopes. No improvement of the main stream for power above the Ohio Pile falls was observed, and but one dam on Castleman's river, a few miles from the mouth.

THE CHEAT RIVER.

Across the eastern part of Randolph county, West Virginia, four forks, known respectively as the Shaver's or Main fork, Glade, Laurel, and Dry forks, flow in a northerly direction, and, successively combining in the southern part of Tucker county, form the main Cheat river. This then follows a somewhat irregular course to the north, and then northwest, passing from Tucker county through Preston and a corner of Monongalia, after which it crosses the state boundary into Pennsylvania, and running about 4 miles farther joins the Monongahela river. In extent of drainage basin it ranks second among the tributaries of that river, its basin including 1,559 square miles. From the head of the Main fork, the extreme source of which is in Pocahontas county, the distance by general course to the Monongahela is 100 miles. The head forks run in narrow valleys between parallel ranges of mountains, and are only 2 or 3 miles distant from one another, while the main river, like the Youghiogheny, cuts in turn across the Briery and Laurel Hill ranges.

The section of country drained by the Cheat river is in general rough and mountainous, especially wild toward the upper waters, sparsely settled, and but little cultivated. At Rowlesburg, a village of 400 inhabitants, the main line of the Baltimore and Ohio railroad crosses the river, but at no other point is it accessible by railroad. The upper basin is heavily timbered with spruce and hemlock, but the only cutting is of poplar, which is obtained principally in Randolph county, driven or rafted down to Rowlesburg, there sawed by steam-power and shipped by rail to eastern markets. About 4,000,000 feet of lumber is estimated to be sawed yearly, the work being carried on by three concerns, of which the largest is the firm of Eberly, Hinkle, & Co. There is said to be no sawing at any other points on the river. On the upper forks there are a few small flouring- and grist-mills that do all the grinding for which there is any demand, and a mile or two below Saint George there is reported to be a small mill on the main stream, but no power is utilized anywhere below. Nevertheless, the river is described as well suited to use for water-power if there were demand for such improvement. The descent is rapid throughout, and especially in the "narrows", in which it cuts through the mountains below Rowlesburg, which is regarded as the most rapid portion of its course. From Rowlesburg to the mouth the total fall is about 546 feet, averaging about 14 feet to the mile. The fall is usually in rapids and ripples joining long eddies or pools. The current is very swift, so much so that it is difficult to hold logs in booms, and this has been the chief obstacle in the way of more extensive lumbering operations on the river. It is considered a fine stream for log-driving and rafting, except in one feature, and that is its obstruction by many large bowlders.

The valley is, in general, narrow and deep, hemmed in by high mountains with steep rugged slopes. Here and there, however, these open out and inclose a fertile intervale of farming land. Such an intervale may be seen just below Rowlesburg from the Baltimore and Ohio railroad opposite, and there is said to be another large opening, a couple of miles more or less in extent, near Saint George. As a rule, the river-bed is composed of ledge rock, probably sandstone, a variety of which, known as "Cheat River bluestone",(*a*) has been extensively quarried at Rowlesburg, shipped to Baltimore, and used in several prominent buildings. At the locality mentioned the Cheat averages about 250 feet in width. It rises rapidly, but not very high, and hardly reaches its height before it begins to recede as quickly as it rose. Mr. Eberly, of the firm of Eberly, Hinkle, & Co., gave the ordinary rise at Rowlesburg as only about 5 feet above extreme low water, and stated that he had never known a freshet there of more than 7 feet, except in one instance, when a height of 10 feet was reached. The stream is sometimes visited by sudden and extraordinarily rapid fluctuations, and is also very deceptive, in accordance with its name of "Cheat". There may be a heavy rain in the country about Rowlesburg without the river's being apparently at all affected; while, again, with the weather fine there, a local storm at some point above will produce a quick and important rise. This action may doubtless be explained by the steep mountainous slopes at the head-waters rapidly shedding the rains of heavy showers into the water-courses, and by the fact that the drainage basin is also rather more expanded there than below. The river runs very low in the dry season, and sometimes continues so for a couple of months.

a In the vicinity of Rowlesburg the prevailing rock is described as being sandstone, mostly red and gray in color. The bluestone is a compact blue sandstone, easily worked and taking a fine finish. It has been used at Baltimore in the office buildings of the Baltimore and Ohio railroad, in the Johns Hopkins hospital, and for other structures.

Estimate of power at Rowlesburg.

Stage of river.	RAINFALL ON BASIN.(a)					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power per foot fall.
	Spring.	Summer.	Autumn.	Winter.	Year.			
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	
Low water, dry year	10	12	9	9	40	*b* 1,096	90	10.2
Low water, average year							130	14.8
Available 10 months, average year							250	28.4

a The rainfall records for the Monongahela basin are very few in number, and the figures here assumed are to be regarded as only roughly approximate.
b Below Salt Lick creek.

THE TYGART'S VALLEY RIVER.

This stream takes its rise a few miles northwesterly from the head of the main fork of the Cheat river, near the extreme southern boundary of Randolph county. It flows northerly through the county, skirting the eastern slope of Rich mountain, then cuts across the ridge, and traverses in succession the counties of Barbour, Taylor, and a portion of Marion, uniting in the latter with the West fork of the Monongahela. Neglecting the minor bends, the Tygart's Valley river has a length of 75 miles. Its drainage basin contains 1,367 square miles, and varies in general in width between 18 and 30 miles. From Grafton to the mouth, a distance which by map measurement appears to be about 18 miles, the right bank of the stream is closely followed by the Baltimore and Ohio railroad, which crosses at the mouth, and at Fairmount, a little beyond, turns abruptly to the west on its way to Wheeling. In the winter of 1882–'83 a narrow-gauge railroad was also being constructed from Grafton up the river toward Philippi, which lies about 15 miles due south; but above the latter point the valley is not accessible by railroad. The town of Grafton has a population of 3,000, and is the only place of much importance on the stream. A few miles above that locality heavy rapids are said to begin, the course lying for a number of miles in a narrow valley, and the river very rough all the way. At Grafton there is a smooth, strong current, the width between banks being 275 or 300 feet. Thence to the mouth the stream lies between high hills which are partially wooded. At times their outlines are well rounded, but again they rise precipitously with rocky sides. Where the hill-slopes are gentle there is some cultivation, but there is scarcely any bottom-land. A mile or two below Grafton there is a considerable shoal, though short. The flow then continues smooth but strong for perhaps half a dozen miles, to Valley Falls, when the character of the stream suddenly changes. It narrows down, and descends rapidly over a rocky bed in successive short pitches occurring at intervals of a few hundred feet through a total distance of between 1 and 2 miles. Thence to the mouth the fall is less rapid, but there are frequent ripples and shoals. The water of the stream is of a decidedly greenish color, in marked contrast to that of the West fork, which was observed to be of a reddish muddy appearance, the line being sharply drawn between the waters of the two for some distance below their junction.

Between Grafton and the mouth of the river there are four dams—one at Valley Falls, and the other three at points below; these latter are low affairs, in one case a mere wing running out to an island, and the use of power, by small grist-mills, is insignificant. The privilege at Valley Falls, some 7 or 8 miles below Grafton, is a fine one, not only from the amount of available fall, but also because of the security and convenience of the site for building. Two abrupt pitches over ledges of sandstone rock occur here in a distance of 200 feet, with a third, less sudden, a little way below. A hill rises steeply on the left, while the opposite bank presents an open space, with a gentle ascent toward the railroad, which is close at hand. At the head of the falls a low framed dam extends across in an irregular line, and a wing running parallel to the right bank diverts water to a saw-mill 300 or 400 feet below. This mill is owned by Theodore Bush & Co., and contains a 62-inch circular saw, and stave machinery; a little power is also employed for a 2-run grist-mill. From the water-surface above the dam to the pool opposite the tail-race the fall is about 26 feet. An additional fall of 15 feet could be gained by extending the head-race 500 feet farther, but the extension would have to be carried through a rocky bank. The available power of the privilege may be estimated as below:

Estimate of power at Valley Falls.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 *foot fall.*	26 *feet fall.*	40 *feet fall.*	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*				
Low water, dry year	10½	12	8½	10	41	1,320	100	11.4	300	460	50±
Low water, average year							170	19.3	500	770	
Available 10 months, average year							280	31.8	830	1,270	

In years past there has been much rafting of hewn timber on this river, but the amount is said to be falling off. Poplar and oak are the principal varieties of trees now cut, the logs being driven down from the upper waters and sawed at various points along the course, usually by steam-power. There is a large amount of sawing done at Grafton and vicinity; and at Bush & Co.'s mill at Valley Falls about 3,000 logs were cut during 1882, furnishing an average of 300 or 400 feet of lumber each.

THE WEST FORK OF THE MONONGAHELA RIVER.

Rising in the western part of Upshur county, the West fork, the only remaining important tributary of the Monongahela to be described, passes westerly into Lewis county, and then by a general northerly course through Harrison county and into Marion, where it joins the Tygart's Valley river. Its length is about 60 miles, measured along the general direction of flow, and the drainage area is 988 square miles, the stream ranking in extent of basin fourth among the tributaries of the Monongahela. The Baltimore and Ohio railroad crosses at Clarksburg, and a short narrow-gauge line runs from that point up the valley to Weston, about 20 miles distant. Other portions of the valley are without direct railroad communication. The places above mentioned are the principal ones on the stream, the town of Clarksburg having in 1880 a population of 2,300, and that of Weston 1,500. The former is a scatteringly-built town, with little manufacturing and apparently little wealth. The country drained by the West fork is mainly an agricultural section, with wheat and corn for its chief productions. The soil, in Harrison county at least, is largely clay and lime, the hills and bottoms both productive, the former especially adapted to the raising of wheat. The timber has been generally cleared away, except about the head-waters of the river, where important amounts of oak and poplar remain; poplar is the only kind of timber, however, of which very much is cut at present, the logs being driven down stream, sawed, and the lumber shipped by rail to be employed in the manufacture of furniture, sashes, doors, blinds, and other articles. No iron worth mentioning is found; but the hills and mountains abound in coal, which is mined to a considerable extent. There is but a moderate amount of coke-burning, and Harrison county is said to contain not more than 50 or 60 ovens.

At Clarksburg the river is 175 feet wide. It is described as having generally in that portion of its course a bed of solid ledge rock, mostly a hard blue sandstone. The banks are usually of good height, composed of clay and loam, with sometimes a little gravel, and are but little overflowed during freshets. There is a good current, with frequent rapids, but there are no abrupt natural falls. Within a short distance from the mouth there is said to be a saw-mill, and at intervals above power is also utilized by small flouring-mills, having in most cases about two runs of stones and employing low falls of from 3 or 4 up to 7 feet. There are eight or ten powers in use, altogether, below Weston, or in say 35 or 40 miles of general course from the mouth. At Clarksburg a fall of 7 feet is used by John R. Steel for a flouring- and saw-mill, the former containing three pairs of buhr-stones, and the latter a 60-inch circular saw. Power is taken from two water-wheels estimated to furnish together 60 horse-power or more. About 2,500 logs were sawed at this mill in 1882, averaging 300 or 400 feet per log. The dam is a framed structure, 12 feet wide at the base, from 7 to 9 feet high, and with 244 feet length of overflow. It was built part in 1867 and part in 1871. The face is carried up vertically and made close with timbers, the interior of the whole structure being compactly filled with rock. A sheeting of oak planks, from 1½ to 2½ inches thick, covers the dam, which rests upon and is bolted to a bed of solid rock. A chute 45 feet wide and 60 feet long permits the passage of logs down stream. At one end of the dam is the mill, while the opposite end is protected by a crib-work abutment 18 by 30 feet in plan. At other points on the river the dams are said to be built variously of stone, hewn timber, and logs, and to stand well.

Estimate of power at Clarksburg.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 *foot fall.*	7 *feet fall.*	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year	10¾	12	8¼	10	41	602	30	3.4	24	60
Low water, average year							50	5.7	40	
Available 10 months, average year							90	10.2	70	

For Steel's mill the supply of water is commonly sufficient nine months in the year for running at full capacity, but during the rest of the time steam has to be relied upon. The stream does not often get very low before June, and in some years no shortage occurs at all, while in others it exists for as long a time as four or even six months, covering most of the period between April and November. The country drained is subject to heavy droughts, which appear to have been aggravated by the general clearing away of timber from the surface, and is not supplied with good springs. During times of unusual scarcity the stream can even be crossed dry-shod at Clarksburg, and the use of water-power has to be entirely abandoned. Not much snow falls in this section, and a depth of 8 or 10 inches is seldom exceeded, even in very rare instances. Ice has been known to form 18 inches thick at Clarksburg,

but commonly it does not reach a greater thickness than 6 or 8 inches, and in some winters there is scarcely any. The West fork is visited by a freshet in April, sometimes by one in June, and important rises are liable to come, now and then, in almost any of the other months of the year; in fact, the phenomena of snow, ice, and rain are all very irregular in their appearance and extent.

Table of utilized power on the Monongahela river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Monongahela river	Ohio river	Pennsylvania	Allegheny	Saw	1	8	70	.....	Port Perry.
Do	do	West Virginia	Monongalia	Flouring and grist	2	9	58	.....	
Do	do	do	Marion	do	1	5	16	.....	
Do	do	do	do	do	2	4½	45	.....	
Sundry small streams	Monongahela river	Pennsylvania	Westmoreland	do	1	10	20	25	
Do	do	do	Washington	do	6	95	135	148	
Do	do	do	do	Saw	1	10	16	.....	
Do	do	do	Greene	do	1	8	30	.....	
Do	do	do	do	Woolen	2	26	22	20	
Do	do	do	do	Flouring and grist	6	87	110	16	
Do	do	do	Fayette	do	10	244+	328	201	
Do	do	do	do	Woolen	2	32	30	30	
Do	do	do	do	Saw	6	69+	81	.....	
Do	do	West Virginia	Monongalia	do	3	29	67	.....	
Do	do	do	do	Flouring and grist	10	113	218	98	
Do	do	do	Marion	do	10	75	174	125	
Do	do	do	do	Saw	4	30	54	.....	
Do	do	do	Preston	Flouring and grist	3	20½	48	25	
Ten-Mile creek and tributaries.	do	Pennsylvania	Greene	do	8	57+	227	130	
Do	do	do	do	Saw	1	8	25	.....	
Do	do	do	Washington	Flouring and grist	6	73½	102	.....	
Youghiogheny river	do	do	Fayette	do	2	6	25+	.....	Connellsville.
Do	do	do	do	Planing	1		30	.....	
Do	do	do	do	Flouring and grist	1	30–34	30±	.....	Falls City.
Do	do	do	do	Wood-pulp	1		350	.....	
Castleman's river and tributaries.	Youghiogheny river	do	Somerset	Flouring and grist	14	208	300	81	One mill returned for main river.
Do	do	do	do	Saw	18	240+	248	.....	
Do	do	do	do	Tannery	1	13	12	.....	
Do	do	do	do	Woolen	6	65	78	32	
Other tributaries	do	do	do	do	2	11	11	.....	
Do	do	do	do	Tannery	1	10	15	.....	
Do	do	do	do	Saw	1	20	16	.....	
Do	do	do	do	Flouring and grist	4	62	70	30	
Do	do	do	Fayette	do	10	233	334	80	
Do	do	do	do	Saw	2	28	7	.....	
Do	do	do	do	Tanneries	2	30	43	.....	
Do	do	do	do	Chair shops	2	15	4	.....	
Do	do	do	Westmoreland	Flouring and grist	4	68	100	55	
Do	do	do	do	Paper	1	20	100	150	
Do	do	do	do	Saw	2	34	45	.....	
Do	do	do	do	Tannery	1	18	8	.....	
Do	do	West Virginia	Preston	Flouring and grist	1	14	10	.....	
Cheat river and tributaries.	Monongahela river	do	do	do	19	280+	335	57	
Do	do	do	do	Saw	8	100	109	.....	
Do	do	do	Tucker	do	2	17	14	.....	
Do	do	do	do	Flouring and grist	1	9	12	.....	
Do	do	do	Monongalia	do	2	12	36	.....	
Do	do	Pennsylvania	Fayette	do	1	10	8	.....	
Tygart's Valley river	do	West Virginia	Marion	Saw	1	26	50±	.....	Valley Falls.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	do	3	17	32	.....	
Do	do	do	Barbour	do	4	16	54	.....	
Do	do	do	Randolph	do	2	35	20	.....	
Tributaries	Tygart's Valley river	do	do	do	4	48	79	.....	
Do	do	do	do	Saw	3	30	44	.....	
Do	do	do	Upshur	do	2	14	28	.....	
Do	do	do	do	Flouring and grist	5	42½	124	.....	
Do	do	do	Barbour	do	7	92	127	35	

Table of utilized power on the Monongahela river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Tributaries	Tygart's Valley river	West Virginia	Preston	Flouring and grist	2	34	40	40	
Do	do	do	do	Saw	1	20	20	.....	
Do	do	do	Taylor	do	2	17	54	.....	
Do	do	do	do	Flouring and grist	5	55½	120	25	
West fork of Monongahela river.	Monongahela river	do	Marion	do	2	8½	20	.....	
Do	do	do	do	Saw	1	4	10	.....	
Do	do	do	Harrison	do	1	7	60	.....	Clarksburg.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	do	1	6	20	.....	
Do	do	do	do	Saw	1		8	.....	
Do	do	do	do	Flouring and grist	1	6	30	30	
Do	do	do	Lewis	do	2	6+	40	64	
Tributaries	West fork of Monongahela river.	do	do	do	3	17	60	30	
Do	do	do	Harrison	do	12	116	330	225	
Do	do	do	do	Saw	2	10	56	18	
Do	do	do	Barbour	do	2	48	30	.....	
Do	do	do	Taylor	Carpentering	1	.....	2	.....	
Do	do	do	do	Furniture	1	.....	2	.....	
Do	do	do	do	Flouring and grist	2	10	33	.....	
Do	do	do	Marion	do	1	7	16	.....	

THE BEAVER RIVER.

This stream may be regarded as formed at the city of New Castle, in Lawrence county, western Pennsylvania, by the union of two tributaries, the Shenango and Neshannock rivers. This junction is about 40 miles northwesterly from Pittsburgh and within 8 miles of the Ohio boundary. From New Castle the course of flow is southerly, passing over a distance probably amounting, if the bends be closely followed, to about 30 miles, and joining the Ohio river at Beaver. Besides the tributaries already mentioned, which come from the northward through Mercer and Crawford counties, the main stream receives from the west, within a short distance below New Castle, the Mahoning river, which drains portions of several of the northeastern counties of Ohio. About midway between the mouth of the Mahoning and the Ohio river Conoquenessing creek enters from the east, and is the last important affluent.

Drainage areas.

	Square miles.
Shenango river at New Castle	765
Neshannock river at New Castle	235
Mahoning river at mouth	1,072
Conoquenessing creek at mouth	810
Beaver river at New Castle, below junction of Shenango and Neshannock rivers	1,000
Beaver river below Mahoning river	2,095
Beaver river below Conoquenessing creek	2,964
Beaver river at mouth	3,030

The territory embraced within the water-shed lines of the Beaver river, amounting, as shown in the preceding statement, to 3,030 square miles, has valuable deposits of coal and iron, is but moderately timbered, and possesses in general a flat or gently-rolling surface. The city of New Castle, at the head of the main river, is an important place, with a population in 1880 of 8,400, and has large iron furnaces. For a mile or two below, the valley appears to range between a quarter and a half mile in width, the river-banks being low and succeeded by wide cultivated flats. The valley then contracts and continues narrow down to Beaver Falls, with high hills rising abruptly from the stream. Through this section the space is too narrow for the convenient location of villages even, and none of importance are encountered; but within 4 miles of the mouth the banks become quite thickly settled, and we find successively the boroughs of Beaver Falls, with 5,100 inhabitants; New Brighton, 3,700; and, at the junction with the Ohio, Rochester on the east and Beaver on the west bank, having populations, respectively, of 2,600 and 1,200.

The Pittsburgh, Fort Wayne, and Chicago, and the Erie and Pittsburgh railroads follow the main river closely, the former ascending for about 9 miles from the mouth, while the latter continues to New Castle and thence up the Shenango river. The Neshannock and Mahoning branches are also closely skirted by railway lines, giving easy

communication in nearly all directions. Years ago the Beaver river possessed a system of slack-water navigation extending from the Ohio river up to New Castle, and from that point connection was had with lake Erie through the Erie canal of Pennsylvania, which followed up the valley of Shenango creek, crossed the water-shed, and descending the valley of Conneaut creek passed on northeasterly to the city of Erie. This navigation route no longer exists, however; the canal has been abandoned, and the only dam between New Castle and Beaver Falls is shortly below the former point.

According to a report made in December, 1867, by W. Milnor Roberts, the fall from the head of New Castle pool to low water in the Ohio river is 129 feet.(a) By the elevations obtained in connection with the second geological survey of the state the fall appears as 133 feet. But of this amount 52 feet, or about 40 per cent., occurs within the 4 miles from the crest of the Beaver Falls dam to the mouth of the river, leaving the balance of 80 feet, more or less, to be distributed over say 25 miles above, in which the average descent is therefore but little over 3 feet per mile. Substantially all of the 52 feet of fall mentioned is included within three privileges: that at Beaver Falls, covering 19 or 20 feet; a second, 1 or 2 miles below, supplying mills both on the New Brighton side and at Fallston, on the opposite bank, and embracing a fall of 16 or 18 feet; and a third at Bridgewater, near the mouth, with a fall of 12 feet. The latter privilege is not utilized for power, and the owners, Messrs. Minor & Co., and M. T. & S. Kennedy, of Fallston, would not willingly lose control, as they depend upon it for locking up rafts from the Ohio river to their mills. This lower portion of the Beaver river is under the influence of freshet backwater from the Ohio, which sometimes causes a rise of 25 or 30 feet below the New Brighton dam, submerges that structure under 10 or 15 feet of water, and at Fallston at least overflows the banks and enters the mills. Serious trouble from backwater lasts from two or three days to one or two weeks. Notwithstanding the quite expensive nature of the improvements at Beaver Falls and New Brighton, the danger and hinderance arising from floods, and the fact that coal can easily and cheaply be obtained, the manufacturers seem well satisfied with their hydraulic power, and consider it more economical for their purposes than steam.

Table of elevations on the Beaver river and its principal tributaries.(a)

Stream.	Locality.	Approximate distance from mouth.(b)	Altitude above ocean-level.	Remarks.
		Miles.	*Feet.*	
Neshannock river	Hope Mills	18.5	1,107	Elevation of rails at station by levels of Oil City and Chicago railroad.
Do	Neshannock Falls	9.0	992	Do.
Do	New Castle (mouth of river)	0.0	799	Water-surface in New Castle pool.
Shenango river	Jamestown	52.5	979	Elevation of rails of the Erie and Pittsburgh railroad at crossing of the Franklin division of the Lake Shore and Michigan Southern railroad.
Do	Shenango	45.0	941	Elevation of rails at station by levels of Erie and Pittsburgh railroad.
Do	Sharon	22.7	853	Do.
Do	New Castle (mouth of river)	0.0	799	Water-surface in New Castle pool.
Mahoning river	Warren, Ohio	35.0	875	Elevation of rails at station by levels of Ashtabula and Pittsburgh railroad.
Do	Mahoningtown	(c)	789	Do.
Beaver river	New Castle	30.0±	799	Water-surface in pool.
Do	Mouth	0.0	666	Low water in Ohio river. W. Milnor Roberts' report of 1870 gives the elevation as 671.57 feet.

a Elevations taken from report on *Levels above Tide, Second Geological Survey of Pennsylvania.*
b By map measurement.
c Close by mouth.

From New Castle down to Beaver Falls the river appears to average as much as 300 feet in width. The dam at the latter point is a fine structure of timber, running straight across the stream, with masonry abutments, vertical face, and no apron; it is about 15 feet high and probably 500 or 600 feet in length. The river-bed is rocky, and rapids extend below the dam. During the period when the Beaver was utilized for navigation, boats passed through a lock and canal at the east end of the dam, and water is still conveyed some distance down that bank to a flouring-mill; but with that exception the power of the privilege is owned and employed on the Beaver Falls or west bank. Water is admitted to a hydraulic race through a substantial timber bulkhead, in which there are five gate-openings, each 5½ feet wide. Each gate is hung by two chains passing over a wooden axle, which is turned by lever-bars and held in place by a ratchet. The fall of this privilege varies somewhat at the different mills, but, as nearly as could be ascertained, amounts to between 19 and 20 feet at the foot of the race. The manufacturing sustained is quite extensive, the largest concerns using power being the Pittsburgh Hinge Company, manufacturing mainly chain and wire, the Beaver Falls Steel Works, and the Beaver Falls Cutlery Company; power is also employed by three planing-mills, a flouring-mill, a pottery, and the borough water-works. The entire power on the race is nominally divided into 200 equal shares, and the oversight of repairs, adjustment of gauge-boards, and other similar duties are intrusted to a committee of the manufacturers. There is commonly a sufficient supply of

a Report to the President and Managers of the Erie Canal Company, of Pennsylvania.

water for all demands, even in a low summer stage, but in exceptionally dry years a shortage has been known to exist for three or four weeks. Ice gives no trouble here of consequence, but the stream is a wild one during freshets, and in an extreme case there has been a depth of 7 feet of water on the dam, the adjoining bank having been submerged at the time. In an ordinary rise, however, there is seldom more than 3 or 4 feet of water running over the dam.

Estimate of power at Beaver Falls.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	19 *feet fall.*	
Low water, dry year	9½	11	10	8½	39	2,994	300	34.1	650	a 590+
Low water, average year							450	51.1	970	
Available 10 months, average year							700	79.5	1,510	

a Returns not complete.

The next dam is a mile or more below the one just described. At the road-bridge between the two the river has a width of about 450 feet. The bed continues rocky, but loses this character a little below the New Brighton dam, and is said to be then composed of gravel and bowlders to a great depth. In construction the dam at New Brighton is described as similar to that at Beaver Falls, it being a timber structure with a height of about 15 feet. There are really three dams in place, each having been built a little below and a little higher than the previous one; the present or main dam was built some ten years ago, and its cost, with abutments, is estimated to have been $20,000. There are rapids below the dam and a race follows down each bank, that on the east being in the borough of New Brighton. On the west side there is an abrupt rise away from the stream, and the race is continued for some distance, down to Fallston, before being drawn upon by mills. The fall in use is stated as 16 feet near the dam on the New Brighton side, but increases somewhat below, and at Fallston is 18 feet, which may be taken as the extreme amount. As at Beaver Falls, the entire power of the privilege is assumed at 200 shares, but here it is equally divided between the two sides of the stream. The New Brighton race is perhaps a quarter of a mile long. The largest establishment supplied from it is the flax-mill of Messrs. Bentley & Gerwig, manufacturers of hemp binding-cord and flax twines, and employing about 160 hands. The New Brighton water-works are operated by power from this race, and it is also drawn upon for running two flouring- and two planing-mills, scouring-works, and a machine-shop—all these of small or moderate size.

On the opposite side of the river the race is probably as much as half a mile long. There is little of interest at Fallston except the mills, which are scattered for a thousand feet along the lower part of the race, close to the river-bank, and not out of reach of high freshets. The principal works here are those of W. P. Townsend & Co., manufacturers of rivets, and M. T. & S. Kennedy, makers of lead-kegs; the Standard Horse Nail Company and the Keystone Portable Steam Driller Company also have works at this point, and power is further utilized by a saw- and planing-mill, a woolen-mill, a grist-mill, a machine-shop, and an establishment for making wooden handles; but these are all comparatively small.

Estimate of power at the New Brighton and Fallston privilege.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	18 *feet fall.*	
Low water, dry year	9½	11	10	8½	39	2,995	300	34.1	610	a 672+
Low water, average year							450	51.1	920	
Available 10 months, average year							700	79.5	1,430	

a Returns not complete.

Both at New Brighton and at Fallston a share of water entitles the owner to draw through an opening of 7½ inches width over a gauge-board or weir. At Fallston, at least, the weirs are adjusted from the results of actual experiments, and are 10 inches lower at the foot of the race than where it is first drawn upon, 1,000 feet above. The power of the privilege is pretty thoroughly utilized in low stages of river. At New Brighton there is not in ordinary years any scarcity of water, and at Fallston the shortage ranges from nothing to a month in duration during different years. At this point there was, when it was visited, in December, 1882, opportunity for another manufacturing concern, for which 7 shares of water could be obtained, and on the New Brighton side it was stated that moderate powers could doubtless be secured. As has already been stated, there is heavy backwater here from the Ohio, but the hinderance does not last long.

Table of utilized power on the Beaver river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H.P.*	*H.P.*
Beaver river (a)	Ohio river	Pennsylvania	Beaver	Blankets, etc	1	Total utilized fall, 37–38 feet.	14	
Do	do	do	do	Coffins, burial cases, and undertakers' goods.	1		90	
Do	do	do	do	Cooperage	1		76	50
Do	do	do	do	Cordage and twine	1		150	200
Do	do	do	do	Cutlery and edge-tools	2		155	120
Do	do	do	do	Flouring and grist	5		245	
Do	do	do	do	Hardware	1		90	
Do	do	do	do	Iron castings and finishings	1		7	
Do	do	do	do	Iron nails, spikes, etc	1		40	
Do	do	do	do	Lead-kegs	1			
Do	do	do	do	Lumber, planed	5		150+	
Do	do	do	do	Machinery	2		10+	15
Do	do	do	do	Pottery	1			
Do	do	do	do	Pumping-works, operated for water-supply.	2			
Do	do	do	do	Rivets	1			
Do	do	do	do	Saw	1		60	
Do	do	do	do	Scouring-works	1			
Do	do	do	do	Steam-drills	1			
Do	do	do	do	Steel-works	1			
Do	do	do	do	Wire	1		80	90
Do	do	do	do	Wooden handles	1		30	
Do	do	do	do	Woolen	1		25	
Conoquenessing creek and tributaries.	Beaver river	do	Butler	do	3	14½+	30	
Do	do	do	do	Saw	3	10+	65	
Do	do	do	do	Flouring and grist	10	210	529	262
Do	do	do	Mercer	Iron castings	1	7	8	
Do	do	do	do	Flouring and grist	7	67	157	
Do	do	do	Lawrence	do	1	22	30	
Do	do	do	Venango	do	1	12	20	
Sundry small streams	do	do	Lawrence	do	1	28	80	85
Do	do	do	do	Woolen	3	33	20	
Mahoning river	do	Ohio	Mahoning	Saw	1	10½	15	
Do	do	do	do	Flouring and grist	1		40	
Do	do	do	do	do	3	29	140	100
Do	do	do	Trumbull	do	1	16	35	
Do	do	do	do	Woolen	1		10	
Do	do	do	do	Saw	1	6½	12	
Do	do	do	do	Flouring and grist	4	28	239	50
Do	do	do	Portage	Flax, dressed	1	5½	15	
Do	do	do	do	Flouring and grist	1	8	50	
Do	do	do	do	Saw	1		20	
Tributaries	Mahoning river	do	do	Cooperage	1	11	25	
Do	do	do	do	Flouring and grist	1	42	17	25
Do	do	do	do	Machinery	1	15	10	20
Do	do	do	do	Sashes, doors, and blinds	1	15	20	
Do	do	do	do	Saw	2	51	35	25
Do	do	do	do	Tannery	1	13	10	
Do	do	do	do	Wooden packing-boxes	1	17	20	25
Do	do	do	Trumbull	Tannery	1	22	10	
Do	do	do	do	Flouring and grist	6	93	165	110
Do	do	do	Columbiana	do	1	14	40	38
Do	do	do	Stark	do	3	35	70	93
Do	do	do	Mahoning	do	2	11	36	
Shenango river	Beaver river	Pennsylvania	Lawrence	do	2	8½	60	
Do	do	do	Mercer	do	1	7	24	
Do	do	do	do	Saw	1		8	
Do	do	do	do	Flouring and grist	8	46	257	
Do	do	do	Crawford	do	1	18	40	
Sundry small tributaries	Shenango river	do	do	do	2	30	65	20
Do	do	do	do	Saw	2	43	37	20
Do	do	do	Lawrence	Flouring and grist	1	18	35	
Do	do	do	Mercer	do	8	80½	269	15

a Power on Beaver river utilized at Beaver Falls, New Brighton, and Fallston.

Table of utilized power on the Beaver river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Sundry small tributaries	Shenango river	Pennsylvania	Mercer	Saw	1	7	30	.....
Do	do	Ohio	Trumbull	Flouring and grist	1	13	14	14
Do	do	do	Ashtabula	do	2	28	50	30
Neshannock river and tributaries	do	Pennsylvania	Lawrence	do	5	77	225	.....
Do	do	do	do	Paper	1	12	40	12
Do	do	do	do	Saw	2	22	44	.....
Do	do	do	do	Woolen	3	21+	36	20
Do	do	do	Mercer	do	1	12	10	.....
Do	do	do	do	Flouring and grist	8	127	172	85
Do	do	do	do	Saw	5	38+	54	.....

THE MUSKINGUM RIVER.

An area of 7,740 square miles, embracing the greater part of eastern Ohio, is tributary to the Muskingum river. Of the total amount, about 4,700 square miles contributes its drainage from above Coshocton, where the Tuscarawas and Walhonding unite to form the main river; one-half of the remainder is gained from Wills creek and the Licking river, and the balance from sundry small creeks. From Coshocton the river flows southerly and then southeasterly to the Ohio, which it joins at Marietta, having passed through a distance of about 110 miles and traversed in succession a portion of Coshocton county and the counties of Muskingum, Morgan, and Washington. The extreme sources of the Walhonding river are in the counties of Richland and Ashland, 35 or 40 miles southeasterly from Sandusky; those of the Tuscarawas are in Medina and Summit counties, 25 or 30 miles southerly from Cleveland. Where the Ohio canal crosses, in the vicinity of Akron, the summit between the adjoining portions of the Cuyahoga and Tuscarawas River basins, the elevation is only about 400 feet above low water in the Ohio at Marietta, and nearly the same above the surface of lake Erie. It is apparent, therefore, that the average descent of the country to the southward toward the Ohio is small, amounting to not much more than 3½ feet per mile if we reckon in a direct line from the summit-level of the canal to the mouth of the Muskingum. From low water at Dresden, 91 miles by river above Marietta, the fall to low water in the Ohio is only 130 feet, an average of about 1.4 foot per mile.

The drainage basin of the river we are considering is quite regular in shape, gradually expanding toward the upper waters, where a width of 90 miles in an east-and-west line is reached. It is rich agriculturally and contains valuable coal-fields. The western boundary of the Pittsburgh coal deposit crosses the Ohio river in the vicinity of Steubenville, and striking southwesterly so as to include a strip in Ohio ranging from 50 miles in width downward approaches the river again in Gallia county; the western limit of the Nelsonville coal deposit runs approximately parallel to the one just described, at a distance beyond varying from 20 to 40 miles. In the southern counties of the Muskingum basin the soil has resulted from the disintegration of the native rocks, and the country is poorly watered; its surface is extremely rough and irregular, cut in every direction by valleys, between which rise high hills. To the northward the surface becomes less broken, though still gently undulating; the soil has been derived from drift materials, is sandy or gravelly in nature, but very fertile, and is variously underlaid by sandstone, shale, coal, and limestone. The summit region about the head-waters of the Tuscarawas and Walhonding rivers is naturally marshy, but during the process of settlement and cultivation its nature has been much modified by drainage, to the detriment of the streams. It is said to be well supplied with springs, however, and in an east-and-west line through Richland and adjoining counties there still stretches an extensive swampy tract.

Drainage areas.

	Square miles.
Licking river	703
Wills creek	815
Walhonding river	2,159
Tuscarawas river	2,547
Muskingum river below junction of Tuscarawas and Walhonding rivers	4,706
Muskingum river at Zanesville, below Licking river	6,565
Muskingum river at McConnelsville	7,178
Muskingum river at mouth	7,740

The average width of the main river is about 500 feet; its waters are hard, and its bed is said to be composed mainly of gravel and ledge rock. The flow is tolerably well sustained in the dry season, but nevertheless falls very low in some years. On the other hand, the river is subject to heavy freshets; but in the lower course, at

least, the banks are of such height that they are seldom overflowed to an important extent, not oftener, it is estimated, than once in 10 years. Rains in the upper basin produce a gradual and sustained effect on the river, while heavy summer showers falling on the steeper slopes of the lower basin sometimes cause sudden and considerable rises at Marietta.

The Ohio canal, ascending, from Cleveland, the valleys of the main and Little Cuyahoga rivers, crosses what is known as the Portage summit, into the basin of the Muskingum river, follows down the course of the Tuscarawas, and afterward that of the main river, to Websport; it then strikes across to the valley of the Licking, which it ascends, and from which it passes over into the basin of the Scioto river. Websport is on the lowest level between the Portage and Licking summits, from each of which there is toward it an uninterrupted descent. There are received therefore into that level, both from the north and from the west, the surplus waters of the canal, which have been supplied to it at various points between the two summits from the streams along its course, and also from reservoirs located on the summits. These surplus waters are discharged into the Muskingum river at Dresden through what is known as the "Muskingum side-cut", a short lateral canal between 2 and 3 miles in length. No accurate data could be obtained as to the amount of water thus discharged, the extent to which the various streams are drawn upon to feed the canal, or the volume of water flowing in the main river and its principal tributaries. When the canal surveys were in progress, nearly sixty years ago, numerous gaugings were made, but were largely confined to the small streams. Since that time, also, this region, once in common with the whole state heavily wooded, has been mainly stripped of its timber, and the character of the streams has without doubt been affected. As nearly as can be ascertained, the tributaries of the Muskingum are now drawn upon for feeding the Ohio canal as follows:

Streams in the Muskingum River basin drawn upon for feeding the Ohio canal.(a)

Name of stream.	Where drawn upon.	Remarks.
Wolf creek	Just below the first lock south of the Portage summit-level.	In 1840 this stream was counted upon to yield, in the driest seasons, 200 or 300 cubic feet of water per minute. Canal crosses by means of a dam.
Tuscarawas river	Clinton, 6 miles from south end of Portage summit-level.	Canal crosses in pool above dam. At lowest stage stream was relied upon for 300 or 400 cubic feet of water per minute.
Meselee creek	Three miles from Clinton	Water received through a feeder 1½ mile long. Stream very constant, formerly yielding at lowest stage about 800 cubic feet per minute.
Mend brook	Three miles above Massillon	A small but constant feeder of about 200 cubic feet per minute. The water received from the above sources, together with that brought from the summit-level, aided by large and numerous springs between Massillon and Bethlehem and in the vicinity of the latter place, supplies the canal to Zoar, in Tuscarawas county, 30 miles from the summit.
Tuscarawas river	Zoar, Tuscarawas county	A short feeder introduces an abundant supply of water, feeding the canal for 21 miles beyond.
Sugar creek	Near Dover	Canal crosses in pool of dam, but, formerly at least, it was not found necessary to draw upon the stream for feeding-purposes.
Tuscarawas river	Half a mile below the mouth of Stillwater creek.	Water received into canal about a mile below Trenton, through a navigable feeder 3¾ miles long, 32 feet wide at water-line, 18 feet wide at bottom, and 4 feet deep. This feeder enters 21 miles below Zoar, and furnishes an abundance of water for the next 30 miles.
Walhonding river	Six miles above Roscoe	Water brought down the Walhonding canal and supplies the main canal to Websport, which is on the lowest level between the Portage and Licking summits.
Licking river	"Narrows of Licking", 10 miles by canal below Newark.	Canal enters pool above dam, and for 2 miles there is slack-water navigation. From this point canal is fed for 17 miles below to Websport.
North fork of Licking river.	Newark	Stream formerly held good for 800 cubic feet per minute in driest seasons, more than sufficient to supply the canal to the "narrows" below.
Raccoon fork	One mile southwest from Newark	At lowest stage was reckoned as only sufficient to supply the level into which it is introduced.

a All the data in this table were taken from the *Fifth Annual Report of the Board of Public Works of the State of Ohio*, rendered January 11, 1842. For access to this and other reports, and for much general information concerning the canals of Ohio, thanks are due to Mr. John B. Gregory, chief engineer of the board of public works.

In addition to the sources of supply above mentioned, this portion of the Ohio canal also receives water from reservoirs on each of the summits. Connected with the Portage summit-level are three small lakes, described in a report of 1842 upon the canal as comprising an aggregate area of 350 acres. One of these—the Summit lake—nearly three-quarters of a mile long, forms part of the canal. The principal supply of water to this summit comes from the upper course of the Tuscarawas, here a small stream, but spoken of in the report just alluded to as remarkable for the uniform quantity of water flowing in it at all seasons of the year, being never less than 1,800 cubic feet per minute.

Although it is not probable that any large reservoirs have been built in Ohio expressly for storing water for hydraulic power, yet their construction is evidently practicable; but there is a question, for the settlement of which little information has been obtained, whether storage of importance would not require too great an outlay to be profitable. In New England, where the storing of water in reservoirs during one-half the year for use during the other half has become so extensive, there are many natural lakes which are taken advantage of and are easily controlled, large tracts of low or swampy land practically worthless for agriculture, the country is well wooded and is underlaid by impervious metamorphic rocks, springs almost everywhere abound, and evaporation is less relatively than in most other parts of the United States. In Ohio, on the other hand, there are few natural lakes of much size. It has been found profitable to drain many of the swamp-lands for purposes of agriculture, the country has been largely denuded of its timber, the hard metamorphic rocks are missing, and strata much more pervious to water supply their place. Springs are abundant in some sections, it is true, but they are very unevenly distributed, in general, and the proportion of rainfall lost in evaporation is considerably larger than in the New England states.

For the benefit of its canal system the state has constructed several large reservoirs, but no data regarding their cost are at hand, except in the single case of the Saint Mary's reservoir, in Mercer county, near the Ohio and Indiana line, covering a surface variously reported at 12,000 and 17,000 acres, and which in one of the canal reports is stated to have cost, in round numbers, $600,000.

On the summit between the Licking and Scioto rivers is what is called the Licking reservoir, which feeds the canal easterly as far as Newark and westerly to the point where the Columbus feeder from the Scioto is received. As originally built, this reservoir extended from west to east nearly 8 miles, with a medium breadth of half a mile, and, when at a level 6 feet above the water-line in the canal, covered an area of nearly 2,500 acres; it was considered capable of furnishing the summit-level and the other levels dependent upon it with water for a period of three months, without any aid from streams, and with these its capacity for supplying the canal was much increased. This, however, was in comparatively early times, when the state was heavily timbered; it has since been found necessary to increase the flowage to about 3,300 acres, and even now the reservoir proves insufficient for the demands made upon it. It was thus described, as first built, perhaps fifty years ago:

> The great reservoir on the Licking summit occupies a natural basin, the bottom of which is a tenacious soil composed principally of clay. This basin was surrounded by higher ground, except on the northwestern side, where the ground was low and flat. A large portion of its area was originally occupied by a chain of small lakes and an extensive marsh. Across the low ground on the northwestern side part of the waters of the South fork of the Licking in times of flood flowed into the marsh, and as the floods subsided returned again into that stream. In order to confine the water in this basin an artificial bank of about 4 miles in length, 2 miles of which also forms the towing-path bank of the canal, was raised across the low ground on the northwestern side; and the waters of the South fork, taken from the stream several miles above, are conducted by a feeder of about 6 miles in length on a higher level into the reservoir, near the southwestern end of which the feeder passes over the canal on an aqueduct and falls into the reservoir.

In order to connect the reservoir with the summit-level of the canal a cut nearly 3 miles long was made, having a maximum depth of about 34 feet and involving the excavation of nearly a million cubic yards of earth, which was found to be composed mainly of blue clay and sand, with small pebbles of stone firmly imbedded.

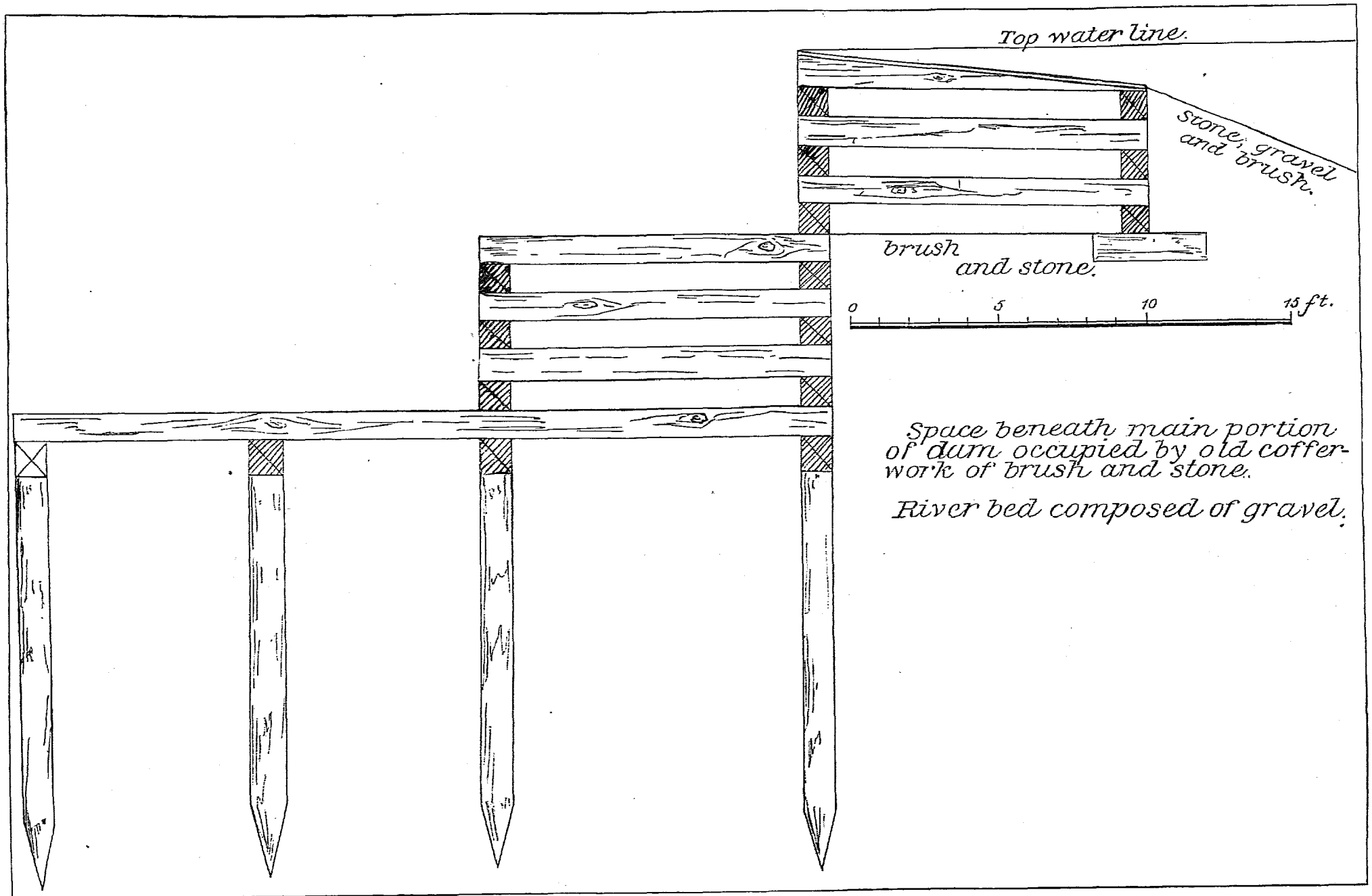
The city of Marietta, which is at the mouth of the Muskingum, had a population of 5,400 in 1880; Harmar, directly across the river, 1,600. Ascending the stream the principal places are the villages of Beverly, 800 inhabitants; Malta, 650; McConnelsville, 1,500; the city of Zanesville, 18,100; Dresden village, 1,200; and Coshocton village, 3,000. In general the basin of this river is well intersected by railroads; the main stream above Zanesville, the Licking, and the Tuscarawas are all followed by railway lines and at the same time command canal navigation, but between Zanesville and the mouth the railroads are distant, most of the way, from 10 to 20 miles on either side, and the adjoining section is more directly dependent upon the river itself for freighting-facilities.

Table showing elevations on the Muskingum river and tributaries.

Locality.	Distance from mouth of Muskingum river.	Elevation of water-surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Walhonding river (Black fork of Mohican creek) at Pittsburgh, Fort Wayne, and Chicago Railroad crossing west of Loudonville.	*a* 151	930.54	237.05	60	3.95	Low-water surface by Pittsburgh, Fort Wayne, and Chicago Railroad levels.
Muskingum river at Dresden, low-water surface.	91	699.49				
Tuscarawas river at railroad-crossing 2 miles north of New Philadelphia.	*a* 154	864.48	164.99	63	2.62	Levels of the Cleveland, Tuscarawas Valley, and Wheeling railroad. Low-water surface of stream 291.4 feet above mean surface of lake Erie.
Muskingum river at Dresden, low-water surface.	91	699.49				
Licking river at railroad-crossing, Newark	*a* 100	791.00	116.00	25	4.64	Low-water surface by levels of Pittsburgh, Cincinnati, and Saint Louis railroad.
Licking river at mouth	75	675.00				
Muskingum river at Dresden	91	699.49	25.35	16	1.58	Elevations obtained by adding to that at Marietta the fall of the river as given in special report of canal commissioners, January 17, 1828.
Muskingum river at foot of Zanesville dam	75	674.14	104.32	75	1.39	
Muskingum river at mouth	0	569.82				Low water in the Ohio at Marietta, as given in report by W. Milnor Roberts, April 21, 1870. (*House Ex. Doc. No. 72, Forty-first Congress, third session.*)

a Distances on the Walhonding, Tuscarawas, and Licking rivers obtained by map measurement, and probably under the truth.

The available water-power of the main river is found chiefly at the dams which were constructed more than forty years ago by the state for creating slack-water navigation. Eleven of these dams were built, extending navigation from the Ohio 91 miles up stream to Dresden, where connection is made through the Muskingum side-cut with the Ohio canal. In extreme low water boats of 3 feet draught can ply on the river, and in an ordinary stage those of 5 feet draught. Several daily lines of steamers run between Marietta and Zanesville, 75 miles above, and weekly round trips are also made between Zanesville and Pittsburgh. The freight on the river is composed mostly of produce and various kinds of merchandise. The shipments down stream are largely made up of wheat, bacon and pork in bulk, and cast iron; those up stream of merchandise, lumber, and bone-dust, and occasionally boats ascend with cargoes of coal and coke. The dams on the Muskingum river are said to have a general similarity in construction, and are crib-work structures resting variously on rock and gravel beds, in the latter case supported,



CROSS-SECTION OF DAM AT MARIETTA.

in part at least, upon piles. In building the Marietta dam, coffer-work of stone and brush was thrown up, directly below which the downstream crib-work of the dam was constructed, resting upon piles and forming an apron to break the force of the overfalling water; the upstream or main crib was then extended back over the coffer-work, utilizing that as its immediate foundation. The ascent around the dams is made through locks and short side-cuts, and averages from 11 to 12 feet between the successive pools, ranging, however, between 8 and 17 feet; below Zanesville the locks built by the state are 175 feet long in the chamber and 36 feet wide.

By the improvements which have been described a total fall of from 100 to 125 feet, and the surplus waters of the river above the demands of lockage, have been rendered available for water-power. These advantages have been utilized, to a moderate extent, continuously since the dams were built. At first the convenient shipping-facilities afforded by the river rendered especially favorable the sites along its course; but with the general introduction of railroads throughout the state the old water-routes of transportation have been largely supplanted, and the lower Muskingum river, being, as we have seen, at some distance from any railway line, is not so attractive to manufacturing-enterprises as it once was, and the use of its power is thought, on the whole, to have declined. At present there are mills at many, though not at all, of the dams; they are chiefly engaged in the manufacture of flour, but there are also reported to be small woolen-mills in successful operation at Beverly and McConnelsville, and at Zanesville there are three wood-working establishments.

The state conveys power to private parties under thirty-year leases. At the end of the time bids are received for the renewal of the privilege. The old lessee has the right of renewing for the same period as before, at the highest *bona fide* bid price. If he does not desire to renew, then the highest bidder as above must take the power at the price offered, and must also purchase all buildings and other appurtenances properly connected with the former use of the privilege, at a price to be fixed by appraisers. There are occasional exceptions to these limited leases, where power had been employed before the state improvements were made. The needs of navigation as regards water must always first be met, and the state also reserves the right to deprive the lessee of water one month in the year, for the purpose of repairing dams and other works, without abatement of rent. The leases specify that water shall be taken over so-called "regulating weirs", which are to be solidly constructed of stone and capped with wood and iron, their crests 6 inches below the surface of water in the pools, or say 6 inches below the crests of the dams. Notwithstanding these directions, there are in fact no regulating weirs in use, at least along the lower river. The rentals charged for water are without any uniformity in rate, little attempt is made to confine lessees to their lawful quantities, and these are in consequence often exceeded. The principle observed in fixing rates seems to have been rather to charge what the lessee could probably afford to pay than to follow any regular schedule of valuation. At Zanesville and Marietta advantage is had of location in cities and of convenient shipping-facilities both by land and by water; power is evidently therefore worth more at those points than at intermediate ones, and the rates charged are higher on the whole, although subject to a wide range. At Beverly we find one lessee paying $60 per annum for 350 cubic feet of water per minute, and another only $100 for 1,200 cubic feet. At Zanesville one lessee is entitled to 625 cubic feet per minute for $83 per annum, while a second pays $800 for 2,200 feet, and a third $500 for 1,100 feet. With very few exceptions, the amounts of water actually used at the different mills are much greater than the lessees are legally entitled to, being in some cases six, eight, and even more than ten times the lawful amount. A few years since, Mr. A. J. Spaulding,(*a*) civil engineer, of Zanesville, was employed by the state to ascertain how much water was really taken under leases at the various points along the canals and the Muskingum improvement. His report showed that upon the latter, under a total of eighteen leases in which water had been conveyed in cubic feet per minute, the aggregate amount thus conveyed was, in round numbers, 23,000 cubic feet, while that used, judging in most cases from the wheel-ratings, was 97,000 cubic feet, or more than four times as great.

Only two of the privileges on this river were visited—those at Marietta and Zanesville. At Marietta the river is about 600 feet wide, and a quarter of a mile or so from the mouth is encountered the first dam. The old lock is on the west side, but at the opposite end of the dam there was being built in 1882-'83 by the government a fine new lock of cut stone, through which steamers and barges employed on the Ohio may ascend to the pool above the dam, and find there a harbor of refuge in winter. The pool is of ample dimensions, having a length of 5½ miles and an average width of about 500 feet. The surplus water at the dam is utilized in part both on the Marietta and the Harmar side. On the former, water is taken from above the dam and carried in a circuitous open channel to Rollston, Hall, & Co.'s flouring-mill, a short distance below. This is a large and fine mill, with elevator, and has an ordinary daily capacity for producing 250 barrels of flour, being furnished with seven pairs of burr-stones and five double sets of rollers. On the Harmar side water is conveyed directly down the bank in an underground wooden trunk, and utilized at Dircks & Co.'s flouring-mill, capacity 150 barrels. With a full pond the fall at the dam is in the neighborhood of 10 feet in ordinary low water. Rollston, Hall, & Co. estimate a loss of about a foot of fall in their race, and place their maximum head at 9 feet, and the average at 6½ or 7. The privilege is subject to back-water from the Ohio, and for an average of about thirty days in the year the mills are deprived altogether of water-power, and must rely upon steam, while for a total of three months the head is seriously affected, ranging down all the way between 6 feet and zero. In June, 1881, there was a depth on the dam of 20.7 feet, due to Ohio back-

a Mr. Spaulding and Mr. William Smith, of Harmar, kindly furnished much information concerning this river.

water, and the same February 23, 1882. There are times during very low water when the supply is somewhat short, and the pool even becomes drawn down a foot or two; but for nearly all the year there is a wastage on the dam, and consequently an available surplus of power. It was stated that when the new government lock should be completed water would be taken in an open cut directly down the Marietta bank to Rollston, Hall, & Co.'s mill instead of following the present roundabout course, and that there would thus be offered sites for more mills. On the Harmar side, also, the state reserves the right to tap the trunk leading to Dircks & Co.'s mill, and there is abundant room for building.

At Zanesville the river is crossed by dam No. 2, below which rocky shoals stretch for some distance. The dam is provided with an apron in two successive pitches, and has abutments rising 17 feet above its crest; but it is said that this height is none too great, and that, even as it is, ice is sometimes forced up on to the masonry. Navigation is accommodated through a side-cut, which from the pool bears well off into the city and enters the river again considerably farther down stream, below the dam and shoals. From this side-cut the mills on the east bank are also supplied with water for power. The full fall practically available is perhaps from 14 to 16 feet, but is not realized by all the mills, and in times of very low water is reduced, and during freshets is liable to be almost or even entirely destroyed. Power is utilized along the side-cut at Cassell & Co.'s flouring-mill, ordinary production 150 barrels per day; at Grant's flouring-mill, 100 barrels capacity; at the Muskingum Coffin Company's works, employing 30 hands; and at Gay Brothers & Silvey's furniture factory, employing 30 hands. On the west side of the river water is drawn from the pool through an independent race and brought to Drone & Co.'s flouring-mill, capacity 250 barrels per day; and some power is also used in Burrow & Ball's furniture works. The lessees recognize no priority of right among themselves in case of scarcity of water, and at such a time each endeavors to supply his wants without regard to the others; disputes are frequent, and the state authorities sometimes have difficulty in shutting off the mills so as to maintain a sufficient depth of water for navigation. In a low stage of river the lessees are sometimes entirely deprived of water-power for a period of perhaps three weeks, usually in the latter part of July and early in August. Late in January the river generally rises, the ice breaks up and runs out, and for from ten days to two weeks the mills are stopped by high water, and for a still longer time suffer more or less reduction of head.

Estimate of power at the various state dams on the Muskingum river.

Locality.	Distance from mouth of river.	Drainage area.	Fall, pool to pool, as given in state report of 1842. (a)	Flow per second, mean for the 24 hours, available 10 months in an average year. (b)	Corresponding theoretical horse-power. (c)	Amount of water leased, as stated in report made a few years since by Mr. A. J. Spaulding.
	Miles.	*Sq. miles.*	*Feet.*	*Cubic feet.*		
Dam No. 1, near Sinm's creek, 6 miles below Dresden..	85	5,705	8	490	445	35.4 cubic feet per second.
Dam No. 2, Zanesville.....	75	5,802	17	500	960	120.4 cubic feet per second.
Dam No. 3, Taylorsville and Duncan's Falls.....	65	6,922	13	590	870	Sufficient for 15 runs of stones.
Dam No. 4, Rokeby and Eagleport	55	7,123	9	600	613	
Dam No. 5, McConnelsvile and Malta.....	48	7,178	9½	610	658	Sufficient for 10 runs of stones.
Dam No. 6, Windsor	38	7,219	11	610	762	26.7 cubic feet per second.
Dam No. 7, Luke's chute	33	7,233	12	610	831	
Dam No. 8, Beverly and Waterford	23	7,625	11	650	812	101.7 cubic feet per second.
Dam No. 9, Lowell	12	7,704	12	650	886	
Dam No. 10, Devoll's.....	5	7,723	10½	660	787	
Dam No. 11, Marietta and Harmar	0	7,740	12	660	900	100 cubic feet per second.
Total.....	.....	.....	125	.....	8,530	

a Lift of locks at low water. The figures given may be considered the limits of available fall, and at some of the dams are never fully realized by the mills as located.

b Liable to reduction for lockage, for which, and the accompanying waste, the maximum demand should not probably exceed 10 cubic feet per second per foot of lockage, except at the large new government lock at Marietta, which has been designed of a capacity 3 or 4 times as great as that of the locks above, and which will require a correspondingly large supply of water.

c In the ten months assumed, however, the power is liable to be completely cut off by backwater for a period ranging, in different parts of the river, from ten days to a month, the latter at the mouth; and to be more or less interrupted through reduction of head for a longer time, reaching at Marietta two months in addition to the one month of complete stoppage.

NOTE.—The effective horse-power may be reckoned at from 60 to 80 per cent. of the theoretical. According to the enumerator's returns there was in use in 1880 a total of 1,100-1,200 rated horse-power of wheels on the entire main river.

TRIBUTARIES OF THE MUSKINGUM RIVER.

The Tuscarawas river includes within its 2,547 square miles of drainage area the greater portions of the counties of Tuscarawas, Harrison, Carroll, and Stark, and lesser proportions of several other counties adjoining these. From the mouth to above New Philadelphia the stream winds through alluvial bottoms, now and then approaching a bluff, which gives it for a time a high bank, but in general one or both banks are low, and in places are subject to annual overflow. The bottoms are fertile and are largely cultivated in corn. Beyond them is a rise to what appear from the valley as ranges of hills, but which are in reality only the swells in the general level of the

country, below which the valley of the stream is depressed. Beginning at a point 3 miles above New Philadelphia, for some 7 miles above the river runs over clay and sandstone rock, and its banks are of good height. Elsewhere the bed of the stream is described as gravelly, the coarser material on the shoals. These shoals are short and occur only occasionally; they are separated by long pools, and the general descent of the stream is slight. The owner of the dam at New Philadelphia claims that it sets back the river for 6 miles. The Tuscarawas is tolerably full and well sustained in volume, and is less rapid in fluctuations than the Walhonding, the other principal affluent of the Muskingum river. In Tuscarawas county the soil is clayey, and hence not very receptive of water, though sufficiently so for all purposes of good farming. Before the general settlement of this district there was much swamp-land in the bottoms and elsewhere, which drained slowly into the stream; but since the country has been cleared surface-waters run off much more readily. In addition to being well adapted to farming, the section tributary to this river possesses valuable beds of coal and of "black-band" ore.

Half a dozen miles below New Philadelphia there is a state feeder-dam across the main stream and a tributary, and a private dam some distance above. From the latter, water is conveyed down to a small mill located near the feeder and discharged after use into that channel. At New Philadelphia, a village of 3,000 inhabitants, Mr. A. Beyer has a fine mill with a capacity for manufacturing 250 barrels of flour per day. The dam, which was built about 1870, is distant a mile up stream and rests on a gravel bed. The latter has been artificially added to, however, by a very large amount of loose stone, estimated at many thousand perches, thrown in during previous futile attempts to maintain a dam. The present structure is 350 feet long, 7 or 8 feet high, and is of stone built up in terraces and bound with timber and iron. Water passes down the left bank in a race to the mill, where a fall of 9 feet is realized. The mill contains 17 sets of rollers, for running which there is claimed to be always more than sufficient power. Mr. Beyer estimates the privilege as suited to a mill of 500 barrels daily capacity during ten months of the year. The principal trouble is from backwater, though that difficulty is not regarded as very serious. At this locality advantage is had of the waters of Conotton and Sugar creeks, which enter the Tuscarawas between New Philadelphia and the Zoar feeder-dam, several miles above. At the latter point power is returned as utilized by several mills and shops. There are flouring-mills also at intervals above well up toward the head-waters.

The Walhonding river is the second important tributary of the Muskingum, its drainage basin containing 2,159 square miles and inclosing, almost entire, the counties of Knox, Richland, Ashland, and Holmes, and covering considerable portions of Coshocton, Wayne, and Morrow. In the vicinity of Coshocton village, where they unite, the Walhonding and Tuscarawas flow through a wide flat valley succeeded by rolling country. Each stream is 250 or 275 feet wide between banks, the latter low. Heavy freshet-rises occur, the oscillations at Coshocton reaching 15 or 16, and even, in extreme cases, from 20 to 22 feet. The Walhonding begins to subside first, and after a general storm invariably reaches its flood stage from twenty-four to forty hours in advance of the Tuscarawas. The availability of the lower river for water-power is chiefly in connection with the Walhonding canal. This leaves the Ohio canal at Roscoe, at the mouth of the river, and ascending along the south bank for 6 miles crosses in the pool of a low dam 3 or 4 feet high, to the north bank, which it then follows for 17½ miles to Cavallo, where there is a second dam a few feet in height. By this dam slack-water is extended 1½ mile to the village of Rochester. The total descent from this pool to the level of the Ohio canal at Roscoe is 90 feet, which is accomplished by 11 locks of cut-stone masonry.

The Walhonding canal was designed to serve both for traffic and as a feeder to the Ohio canal. Except in one or two years the navigation is said never to have been large enough to make it profitable, and recently the 17 or 18 miles above the lower dam was sold by the state to the Mount Vernon, Coshocton, and Wheeling Railroad Company, a new enterprise, and will no longer be used for boats. The company considers that the canal offers a good water-power, which it intends to maintain and lease. Mills would naturally be located at the locks, although there are opportunities for discharging directly into the river; but it is of course more desireable that the water should be used over and over. A right is also owned by this company to construct its track on the canal-bank for the 6 miles from the lower dam to Roscoe, but it does not own that portion of the canal, and the latter is nominally to be kept open by the state for navigation, and more especially as a feeder.

At Roscoe the Walhonding canal descends by three locks into the Ohio canal, and from the upper level water is drawn to supply the large flouring-mill of Barney, DeMoss, & Co., and a small woolen-mill, both discharging under a head of 24 feet into the Ohio canal. The flouring-mill has a capacity of 200 barrels per day, and uses about 125 horse-power. The power is stated to be very constant, with no interruptions from ice or low water. It is estimated that if the canal is maintained in proper condition there will be a uniform flow through this portion of at least 7,000 cubic feet per minute. It has been allowed to silt up somewhat, however, and needs dredging. From Cavallo to the mouth of the river the only use of power, aside from that just described, is by a flouring-mill at Walhonding village, some 18 miles up stream, and by a custom-mill at Warsaw, 8 miles from Roscoe, both mills of fair size. Assuming that an average flow of 100 cubic feet per second can be maintained throughout the length of the canal, the available power will be in the neighborhood of 1,000 theoretical, or say from 600 to 800 effective, horse-power.

The Licking river.—In Newark township, near the center of Licking county, three branches, known respectively as the North, Middle or Raccoon, and South forks, unite to form the main Licking river, which then pursues an easterly course into, and nearly to the center of, Muskingum county, passing through a distance of about 25 miles, with a descent of 116 feet, and entering the Muskingum river at Zanesville immediately below the state dam. The country

bordering the main river, at least, is well supplied with springs, and the volume of flow is said to be very well maintained; nevertheless it is not so well maintained as it was before the country was cleared up, and men long acquainted with this section are positive in their statements that there has been in forty years a decided shrinkage in the streams, forcing the abandonment of many small powers. In order to feed the Ohio canal the Raccoon fork is drawn upon 1 mile to the southwest of Newark, the North fork contributes a supply through a feeder at that city, and some 10 miles down stream a state dam controls the entire flow of the main river. The great Licking reservoir of over 3,000 acres, on the summit between this river and the Scioto, has already been described. The stream runs smoothly in general, with a moderate current. The banks along the lower course are of good height, and are but little overflowed in freshets.

Close by the mouth Messrs. Hook Brothers & Aston have a flouring-mill with 11 runs of stones and a capacity for producing 175 barrels of flour per day. The dam was built twenty years or more ago, and is a framed structure 300 feet long by about 8 feet in height. It rests upon a bed of limestone between 2 and 3 feet thick, which is said to extend up the stream and underneath which is found slate rock. A fall of 7½ feet is obtained at the mill, and 128 horse-power is in use. During three or four months in the year there is more or less shortage of water. The pond extends about a mile up from the dam, but is insufficient for storing the night flow unless in an exceedingly dry season; at all other times, with the mill stopped there is certain to be a wastage over the dam before morning.

About 4 miles above Zanesville are what are known as the "Falls of Licking". The river valley is here narrow, and the stream itself descends in rapids for a distance of a quarter of a mile, accomplishing a descent which was found by pocket-level to be in the neighborhood of 15 feet. The bed is rocky, and the principal fall occurs near the foot of the rapids, where the strata dip considerably to the south. At the head of the rapids there is said to be a pool 12 or 15 feet deep; the rocks thus form a natural dam, and it is considered that the privilege could be improved by simply cutting a channel down from this pool. Above the rapids there is an alluvial flat where the banks are low, but thence down past the falls they are high and composed in part of soil and in part of rock. The river is here perhaps 250 or 300 feet wide. If it were desired, a dam could be thrown across near the head of the rapids and water brought down the left bank, and a fine location found for a mill near the foot of the falls. Probably no objection would be raised against the building of a dam of moderate height on the score of aggravating the danger of submergence to land above; on the other hand, it would check the current of the stream and prevent a washing of the banks which now goes on, and it is said that parties have even petitioned to be allowed to construct a dam for that purpose alone. The privilege belongs to the estate of the late A. H. Brown, of Zanesville. It was formerly in use to some extent, but no power is now employed, except in an insignificant way by a little clay-mill having a short wing-dam.

Two or three miles above, at Claypool, there is a flouring-mill, and there was also said to be a saw-mill at the Licking feeder-dam, but no other power was mentioned as being in use on the main river. The various forks in Licking county furnish power to a number of small flouring-mills, but are not regarded as of especial value. Their beds are gravelly, the banks are composed of gravel and loam, and it is found difficult to maintain tight dams. The North fork is at Newark about 80 feet wide.

Wills creek enters the Muskingum river from the east about 8 miles south of Coshocton. It drains the greater part of Guernsey county, together with portions of several surrounding counties, its basin embracing 815 square miles. A number of small flouring- and saw-mills are found on the tributaries, as well as on the main stream, but the latter is extremely crooked and sluggish, with an average descent, as stated by Professor Orton, not exceeding a foot per mile for nearly its whole length, and is of little importance.

Table of utilized power on the Muskingum river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Muskingum river	Ohio river	Ohio	Washington	Flouring and grist	2	7–9	190±	60	Marietta and Harmar.
Do	do	do	do	do	2	12	55		Adams.
Do	do	do	do	Saw	1		20		
Do	do	do	do	Agricultural implements	1	0	30		Beverly.
Do	do	do	do	Flouring and grist	3		105		
Do	do	do	do	Woolen	2		55		
Do	do	do	Morgan	Flouring and grist	2	8–11	130		
Do	do	do	Muskingum	do	2	9	48		Harrison and Wayne.
Do	do	do	do	do	3	14–16	482		Zanesville.
Do	do	do	do	Furniture	2		10+		
Do	do	do	do	Coffins and burial-cases	1		40		
Sundry small tributaries.	Muskingum river.	do	Washington	Flouring and grist	3	27	99		
Do	do	do	do	Saw	3	21	60		

THE LITTLE KANAWHA RIVER.

Drainage areas.

	Square miles.
West fork of Little Kanawha	210
Hughes river, branch of Little Kanawha	660
Little Kanawha at Burning Springs	1,190
Little Kanawha at mouth	2,290

The sources of this river are in the southern part of Upshur county, West Virginia, whence it takes a northwesterly direction across the counties of Branton, Gilmer, Calhoun, Wirt, and Wood, to Parkersburg, where it empties into the Ohio. In an air-line the distance from the extreme head to the mouth is about 85 miles, but this is increased to 160 miles or more when we follow the meanderings of the stream. The Little Kanawha river has not much value for power, except, as hereafter to be seen, at the navigation company's dams. In the more important part of its course the fall is small, averaging only about 1½ foot per mile for 130 miles above the mouth. About the year 1874 a survey nearly to the head-waters was made by government engineers, and the fall found as below:

Table showing the fall in the Little Kanawha river.

Locality.	Distance above mouth.	Elevation of water-surface above low tide in ocean.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Bulltown	130.75	702.3	87.75	147.5	1.68
Mouth of Spring creek	43.00	614.8			
Mouth of Little Kanawha river	0.00	a 562.8	43.00	52.0	1.21

a Elevation of low water in the Ohio river by W. Milnor Roberts' report of 1870, 563.69 feet.

The Little Kanawha Navigation Company has four locks and dams on the lower river for slack-water navigation. The dams are uniformly about 16 feet high above foundation, and the locks have each a lift of 12 feet at an ordinary low stage of river. Three boats ply regularly on the stream, and carry on a very considerable amount of traffic, which is increasing. Since the organization of the navigation company its receipts from tolls have advanced from about $9,000 to nearly $30,000 per year. Four-foot slack-water navigation is maintained from the mouth to Burning Springs, 40 miles above, and in 1882 the national government was building a dam still above, which was to extend slack-water somewhat farther.

At the second dam from the mouth the construction of a small grist-mill was begun, but not completed, and at the fourth dam a 2-run grist-mill is steadily in operation, obtaining its power at a rental of $150 per annum. Farther than this the writer could gain no knowledge of any utilization of the stream for power. The navigation company is anxious to have the surplus power at its dams put to use, and has made efforts to secure such a result, but with very little success. Abundance of water could be relied upon for about nine months in the year, but there seems to be scarcely any demand for hydraulic power in this section. The owners of the saw-mills find it to their advantage to burn up waste and run by steam, and there is otherwise but an insignificant amount of milling. This section is naturally fertile, but in years past the land has been drawn upon heavily for tobacco culture without being enriched in return, and has thus become badly run down. It is naturally a blue-grass region and finely adapted to grazing, but stock-raising is carried on only to a very moderate extent, though it is increasing. As for wheat, there actually is not enough raised for the local supply, and flour has even to be shipped up the river. If a farmer wants wheat or corn ground, it is only a sack or two at a time; none is ground for feeding stock, and there evidently can be but little business for flouring- and grist-mills.

The great industry along the Little Kanawha is lumbering. Poplar is the prevailing timber found, and the principal operations are in that variety, though there are also considerable proportions growing of oak, walnut, and yellow pine. The logs are cut all over the surrounding country, from 50 to 175 miles above the mouth of the river, floated down stream in rafts, usually about 120 feet long by from 20 to 24 feet wide, sawed up in mills scattered along the banks, and made into lumber, staves, and cross-ties. There are three large saw-mills at Elizabeth, and numerous others toward the mouth, and at Parkersburg, which is an active place of about 6,600 inhabitants. For a few miles above the mouth the river is followed by the Baltimore and Ohio railroad, but nowhere else is the main stream directly accessible by rail.

Toward Parkersburg the valley is wide and the river runs between banks of fair height, which are succeeded by comparatively level alluvial land. Far up the stream the banks are said to be alluvial, but the bed is in the main composed of sandstone rock, which is rather soft, so that it is sometimes torn up in large blocks by the overfalling water at the dams, and especially by drift coming over them. Its distribution is very peculiar. Though occurring generally in the bed of the stream it seldom extends clear across, but runs out, sometimes from one bank

and sometimes from the other, perhaps nearly or quite to the opposite bank, and then suddenly drops away. Thus the navigation company's dam No. 1 rests upon rock, while the lock had to be supported upon piling; and it is stated that a rock foundation was found also for the new government dam and for the river-wall of the accompanying lock, but that at the site of the shore-wall borings to a depth of 50 feet failed to strike any rock. It seems probable that the river once ran in a deep channel, somewhat different in course from the present one, and that the old channel has been filled and the river forced over upon what were at some time its banks.

In common with most streams in this section the Little Kanawha is subject to great fluctuations in volume. It rises very rapidly, and apparently with slight provocation. A rise of a foot an hour is not uncommon, and Mr. L. B. Dellicker, of the navigation company, from whom most of the information presented regarding this river was obtained, has known a rise of 28 feet in twenty-four hours. The country drained is characterized by steep slopes, or, as was described, "is all on edge", so that rains are quickly shed into the creeks and small streams. Again, the slope of the river is small, as we have already seen, its channel is very winding, and it is unable to carry off the floods of water as rapidly as they are received. According to a rough measurement on the map of the government survey, the distance from Bulltown to the mouth was found to be by general course about 72 miles, against 131 miles by river.

On the other hand, the volume runs very low in the dry season, and often it is only by the very closest economy that the navigation company can command enough water for lockage purposes. In the summer and autumn of 1881 there was no waste over the dams for three months. It is difficult to account for such a state of things. Evaporation is undoubtedly large, but the chief trouble seems to lie in a deficiency of good springs. The soil throughout this section is deep, and is underlaid by porous sandstone rock. It was stated that up the Little Kanawha valley oil-wells have been sunk many hundreds of feet, nearly all of the way through rock, without encountering any water whatever. It seems probable that, while an important part of the rainfall drains off at once, considerable is absorbed by the deep soil and afterward evaporated from the surface, and much percolates to depths too great to allow of its reaching the water-courses.

Table of utilized power on the Little Kanawha river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Little Kanawha river	Ohio river	West Virginia	Wirt	Flouring and grist	1	10	30	.....
Do	....do	....do	Gilmer	....do	1	4	15	.....
Do	....do	....do	....do	....do	1	5½	20	.....
Do	....do	....do	....do	Saw	1		20	.....
Do	....do	....do	Braxton	Flouring and grist	1	15	20	.....
Do	....do	....do	Upshur	....do	1	13	30	.....
Do	....do	....do	....do	Saw	1	12	12	.....
Hughes river and tributaries	Little Kanawha river.	....do	Wirt	....do	1	6	15	.....
Do	....do	....do	....do	Flouring and grist	1		30	.....
Do	....do	....do	Ritchie	....do	9	58	215	.....
All other tributaries	....do	....do	Wood	....do	1	6	16	.....
Do	....do	....do	Wirt	....do	1	7	8	.....
Do	....do	....do	Gilmer	....do	2	9	26	16
Do	....do	... do	Roane	....do	4	24	40	.....
Do	....do	....do	Braxton	....do	1	7	12	.....

THE SCIOTO RIVER.

This river, which receives the drainage from 6,400 square miles of territory, has its source in western Ohio, in the county of Auglaize. The surrounding region is the most elevated in the state, the greatest altitude, 1,544 feet,(*a*) being reached within 3 miles of the village of Bellefontaine, or in the neighborhood of 20 miles to the southeastward from the source of the Scioto. To the north are the basins of the Maumee and Sandusky rivers, flowing into lake Erie. In a report made more than 50 years ago by the Hon. John Geddes, the country at the head-waters of the Scioto and Sandusky was described as extremely unfavorable to the formation of durable streams, the soil being of such a character as to shed water freely and to give great unevenness in flow to the brooks and creeks. From its origin in the eastern part of Auglaize county the course of the river we are considering is easterly for about 40 miles, through the counties of Hardin and Marion; in the latter the direction of flow changes

a According to Professor Edward Orton, of Columbus, who kindly furnished much general information concerning the streams and topography of Ohio.

to southerly, and remains so until the Ohio is joined at Portsmouth, the river having in the mean time traversed successively the counties of Delaware, Franklin, Pickaway, Ross, Pike, and Scioto. By general course the length of the river is 170 miles; following the bends with tolerable closeness on the map, the distance from source to mouth is about 210 miles, and even this is probably less than the true distance by water. Assuming the elevation at the extreme head-waters of the river to be as great as 1,400 feet, the total fall thence to the mouth may be stated approximately as lying between 900 and 1,000 feet. From a point southwest of Marion the descent to Portsmouth is a little over 430 feet, the average slope being about 5 feet per mile to Columbus, and the remainder of the way about 2 feet per mile.

Table showing the fall in the Scioto river.

Locality.	Distance from mouth.	Elevation of water-surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Extreme source of river	210	1,400±	500±	58	(8-9) ±	Estimated roughly.
Crossing by New York, Pennsylvania, and Ohio railroad at Green Camp, southwest of Marion.	152	900	207½	42	4.94	Water-surface by elevations of the New York, Pennsylvania, and Ohio railroad.
Columbus, crest of state dam	110	692½	225	110	2.05	Elevation obtained by adding to level of low water in the Ohio river 225 feet fall, as given in state canal report of 1842.
Mouth of river, low water in the Ohio	0	467½				Exact elevation given as 467.526 feet in report of April, 1870, by W. Milnor Roberts.

The basin of the Scioto is a good farming section, and is intersected in various directions by railroad lines, most of which converge at Columbus, a fine city of 50,000 inhabitants. The other principal points on the immediate course of the river are the cities of Portsmouth and Chillicothe, each with a population of about 11,000, and Circleville with 6,000. The upper river, as far as to Delaware county, lies in the drift formation, in which the banks are ill-defined and the valley is flat. Next it enters upon the region of Devonian limestone, and the valley becomes of a rocky character, and so continues nearly to Columbus. This formation is succeeded by the Devonian black shale, which has been widely eroded and the space occupied by drift. From Columbus to the southern boundary of Pickaway county the river runs through a broad productive valley ranging from 3 to 5 miles in width in general, but spreading out in the "Pickaway plains" much wider and very flat. The valley lands are gravelly in character, said to be usually worth from $100 to $150 per acre, and are mainly cultivated in corn. The uplands are composed of rock covered with a sandy or clayey soil, and are devoted chiefly to wheat and grass. Below Pickaway county the river traverses the region of Waverly sandstone, walls of which, often obscured by slopes of disintegrated material, are to be found on either side of a broad valley, which is to a considerable extent subject to inundation by the Scioto and by backwater from the Ohio river. Three successive bottoms are here to be distinguished: The first, or lowest, is overflowed by every high flood; the second, by extreme freshets; while the third is 50 or 60 feet above low water, and beyond danger of submergence. Along the lower Scioto the bottom-lands yield splendid crops, mainly of corn, but the uplands are of much poorer character, are occupied by a far less thrifty class of farmers, and show but few important villages. There is a large amount of timber still standing in southern Ohio, and in the lower Scioto basin and vicinity a great many hoop-poles and barrel-staves are made and much tan-bark is stripped. The principal variety of timber is said to be oak, though it has largely been cut away, and there is also some poplar and pitch-pine.

In its downward course the Scioto receives at Columbus its first large tributary, the *Olentangy*, which joins it from the north and drains 547 square miles. Below Columbus the principal affluent entering from the east is *Big Walnut creek*, while from the west come *Darby*, *Deer*, and *Paint creeks*, the drainage areas of which are given elsewhere. These streams and various other tributaries of the Scioto are utilized to a much greater extent than the main river for water-power, being more easily controlled and carrying sufficient water ordinarily for the demands of the small flouring- and saw-mills located upon them. Above Columbus, in Franklin and Delaware counties, there are a number of flouring-mills on the Scioto itself, but from that city down the river is not utilized for power, so far as ascertained, at any point. Nor does this portion seem to be, as a whole, at all well suited to such employment. The bed is generally gravelly, the banks are low, and at many points protected against inundation only by means of levees; the course is very winding, the flow smooth, with scarcely a ripple, and, as we have already seen, the average descent is small, not exceeding about 2 feet per mile. High freshets occur in spring and early summer, with an extreme rise in the lower river, from Waverly to the mouth, of from 20 to 21 feet above low water. The mean annual rainfall on the entire basin of this river is approximately 38 inches, distributed as follows: 10 inches in spring, 11½ in summer, 8 in autumn, and 8½ in winter. About the year 1823 or 1824, when surveys were in progress for the Ohio canals, measurements were made of the low-water flow in various streams, among others the Scioto. The discharge of this stream at Columbus was found to be 1,500 cubic feet per minute, or 25 cubic feet per second, and at the mouth of Deer creek, about 10 miles north of Chillicothe, was estimated to be 4,000 cubic feet

per minute, equivalent to 66 cubic feet per second.(a) Supposing, as is probable, that the measurement at Columbus was made below the mouth of the Olentangy, where the tributary drainage area amounts to 1,686 square miles, the discharge noted corresponded to an average of only 0.015 cubic foot per second per square mile, while that assumed at the mouth of Deer creek was at about the same rate, or say 0.017 cubic foot per second to the square mile. The rate of flow thus determined is remarkably small, and is even difficult to accept as correct; but it is evident that in times of severe drought the country at the head-waters of this river affords but a scanty supply of water; in fact it was stated in the canal commissioners' report of 1824 that "the Scioto, in a very dry season, above the mouth of Rush creek (Marion county) exhausts by evaporation and absorption nearly all the waters which it receives". No recent measurements of the volume of this river were learned of, but it is improbable that the extreme low-water rate of discharge has materially increased above what it was sixty years ago.

Including the one at Columbus there are three dams on the Scioto from that city to the mouth of the river, all owned by the state and utilized in feeding the Ohio canal. This canal descends westerly from Licking summit, passing down the valley of Little Walnut creek, from which, as well as from Roger's run and Black Lick creek, it receives small supplies of water; and then, as it approaches the course of the Scioto it crosses to the valley of Big Walnut creek, and at Lockbourne is joined by the Columbus feeder. This feeder is 11¾ miles long, and is navigable. It opens out from a pool formed at Columbus by a dam across the Scioto, and descends on the east side of that river to a junction with the main canal, just before reaching which it crosses Big Walnut creek in the slack-water of a dam, thus commanding also the flow of that stream. From Lockbourne the main canal runs southerly on the east side of the Scioto, crossing Little Walnut creek again near its mouth in the pool of a dam and rendering the stream again tributary as a feeder. At Circleville, in Pickaway county, it crosses on an aqueduct to the west side of the Scioto, and 2 miles below the city receives water from the river through a short feeder. The latter opens from the slack-water created by a dam described as 400 feet long, 7 feet high, and constructed of piles. Six miles below Chillicothe still another dam across the Scioto, of about the same height as that at Circleville, diverts into the canal water sufficient to meet the demands of navigation thence to the Ohio.

Drainage areas of the Scioto river and tributaries.

	Square miles.
Olentangy river at mouth (Columbus)	547
Big Walnut creek at mouth	513
Darby creek at mouth	592
Deer creek at mouth	423
North fork of Paint creek	236
Main fork of Paint creek above junction with North fork	828
Paint creek at mouth	1,083
Scioto river at southern boundary of Marion county	628
Scioto river at Columbus, above junction with Olentangy river	1,139
Scioto river at Columbus, below junction with Olentangy river	1,686
Scioto river at Circleville, below Darby creek	3,275
Scioto river at Chillicothe	3,923
Scioto river at mouth	6,400

Table of utilized power on the Scioto river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Scioto river	Ohio river	Ohio	Franklin	Flouring and grist	5	93½	120	.....
Do	....do	....do	Delaware	....do	3	20½	73	.....
Do	....do	....do	....do	Saw	2	11	45	.....
Tributaries	Scioto river	....do	Morrow	Flouring and grist	5	68½	149	25
Do	....do	....do	Marion	....do	2	15½	66	80
Do	....do	....do	....do	Saw	1	6	20	.....
Do	....do	....do	Union	....do	1	5	27	.....
Do	....do	....do	....do	Flouring and grist	2	17	33	35
Do	....do	....do	Delaware	....do	9	92	322	145
Do	....do	....do	....do	Paper	2	22	105	120
Do	....do	....do	....do	Saw	4	23½	81	.....
Do	....do	....do	Franklin	....do	1	4	16	.....
Do	....do	....do	....do	Flouring and grist	6	37	188	.....
Do	....do	....do	Madison	....do	5	50+	169	.....
Do	....do	....do	Champaign	....do	3	52	60	40
Do	....do	....do	....do	Saw	3	50	75	.....

a Report by David S. Bates, principal engineer, in *Third Annual Report of Canal Commissioners*, January 8, 1825.

Table of utilized power on the Scioto river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall utilized.	Total water-power utilized	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Tributaries	Scioto river	Ohio	Champaign	Woolen	2	12+	25	.....
Do	do	do	Fayette	Flouring and grist	3	25	54	35
Do	do	do	do	Saw	1	8	8	.....
Do	do	do	Pickaway	do	2	20	37	.....
Do	do	do	do	Flouring and grist	9	103	212	.....
Do	do	do	Fairfield	do	2	53	40	.....
Do	do	do	do	Saw	1	23	20	.....
Do	do	do	Hocking	do	2	13	16	.....
Do	do	do	do	Flouring and grist	4	41	86	.....
Do	do	do	Ross	do	9	81½	284	100
Do	do	do	do	Saw	3	23	66	.....
Do	do	do	do	Woolen	1	7	9	.....
Do	do	do	Vinton	Flouring and grist	1	.....	10	24
Do	do	do	do	Saw	1	4	8	.....
Do	do	do	Highland	do	2	20	40	.....
Do	do	do	do	Woolen	4	79	112	30
Do	do	do	do	Flouring and grist	11	114	288	137
Do	do	do	Adams	do	1	12	30	20
Do	do	do	Scioto	Saw	3	30	45	.....

THE GREAT MIAMI RIVER.

The main branch of the Great Miami river takes its rise in the central part of western Ohio, being formed by small streams heading in Logan and Hardin counties. Thence the general direction of flow is southwesterly to the Ohio river, which is joined in the extreme corner of the state, almost upon the boundary between it and Indiana. In a length which by general course is about 120 miles, this river traverses in turn the counties of Logan, Shelby, Miami, Montgomery, a corner of Warren, Butler, and Hamilton. Whitewater river, draining 1,482 square miles, is the largest tributary received, uniting with the main stream within a few miles of its mouth. In the middle course there enters from the west the Southwest branch, with a drainage basin of 710 square miles, and from the east Mad river, which drains 585 square miles.

The entire area naturally tributary to the Miami river comprises about 5,400 square miles, of which between 1,400 and 1,500 lie in Indiana. The southwestern portion of Ohio possesses a limestone soil, and is the most fertile part of the state. It is more thickly settled than any other section, contains numerous cities and large villages, is intersected in all directions by railroads, and is rich and prosperous. Attendant upon this prosperity, and contributing toward it in a large degree, has taken place an important growth in manufacturing-interests. These are much diversified, and are carried on both by steam- and by water-power; but in connection with the latter form of motive power is to be noticed especially the development of paper-manufacturing. The history of this industry in the Miami valley is included within the past thirty-five years. The processes at first employed in the manufacture were rude, and there were few mills; but the success of some of the early enterprises, and the natural advantages offered by this section of Ohio, have led to a large increase in the number of establishments, and the methods of manufacture have at the same time made great advances. According to the annual report of the secretary of state for 1879 there was produced in the fiscal year 1878–'79 at the mills of 27 firms or companies tributary to Cincinnati, located mainly along the Miami river and the Miami and Erie canal, paper as follows:

Kinds.	Pounds.	Value.
Book	11,497,694	$1,010,061
Manila	10,204,528	672,700
News	8,063,072	530,466
Roofing	5,350,210	144,194
Wrapping	10,438,455	244,347
Writing	1,817,000	240,000
Total	48,366,008	2,859,768

Some of the advantages enjoyed by this industry in the Miami valley consist of location in a section possessing much capital; fine conveniences for transportation, both by rail and by canal; and, not least, an abundant supply of pure wash-water, which is easily obtained from the gravelly subsoil, either by open or by driven wells. Straw is

plentifully and cheaply obtained, and some chemical straw-pulp is made in the valley. Poplar for wood-pulp can be found to a moderate extent in the northern part of the state, but the great bulk of the wood-pulp used is manufactured in, and shipped from, the northwest, especially Michigan.

Although its drainage basin is not large—the area tributary to that portion of the river mainly utilized ranging only from 1,900 to 3,300 square miles—nevertheless the stream has been improved to a considerable extent for power in the manufacture not only of paper, but also of flour, machinery, and various other goods. Its value for power arises from the advantages of location and communication which have already been noticed, and also from the possession of a more rapid fall in its main course, and a fuller and better-maintained volume of flow than characterize other streams of equal drainage area in this region. This character as regards flow is due to the abundance of permanent springs. In the report of surveys made fifty years or more ago, by the Hon. John Geddes, of the country between lake Erie and the Ohio river, it was stated that "the Great Miami has its source in a country the formation of which is very favorable to living springs". In the section drained by Mad river is extensively found a peat-like deposit which retains water like a sponge and gives to that stream a very uniform discharge. The northern and western portions of Ohio are covered by drift. In the southwestern part of the state, in the Miami valley, this is underlaid by the blue limestone formation, itself entirely impervious to water, but fringed along its border with fine springs.

Although in Logan county the surface of the country attains an elevation of over 1,500 feet above tide, the altitude of the dividing ridge between the Miami and Maumee rivers is in places much less, and, according to the original surveys for the Miami canal, is only 970 feet at the point where it was designed to carry across the summit-level. From Piqua to the mouth of the river, a distance of say 108 miles, the fall in water-surface is between 420 and 425 feet, an average of nearly 4 feet per mile, and that average rate of descent holds even in the lower 55 miles.

Table showing the fall in the Great Miami and Mad rivers.

Locality.	Distance from mouth.	Height of water-surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
Great Miami river.	*Miles.*	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Maumee-and-Miami summit	.....	972	.....	.....	.....	Height of summit by original survey for Miami canal.
Piqua	108	840	124	31	4.00	Height of low water at crossing of the Pittsburgh, Cincinnati, and Saint Louis railroad, according to the profile of that road.
Dayton	77	725	69	23	3.14	Low-water surface of stream at crossing of the Cincinnati, Hamilton, and Dayton railroad is 295.45 feet above low water in the Ohio river at Cincinnati; the latter is assumed as 430.74 feet above sea-level, as determined by Mr. James T. Gardner.
Middletown	55	656	229	55	4.16	Obtained by adding to low water at Cincinnati the fall of the Miami and Erie canal, as given in canal report.
Mouth of river	0	427				Elevation of low water in the Ohio river, by survey of W. Milnor Roberts, 426.617 feet above ocean-level (see *House Ex. Doc. No. 72, Forty-first Congress, third session*).
Mad river.						
Four and a half miles west of Springfield.	21	888	163	21	7.76	Level of low-water surface at Indiana, Bloomington, and Western Railway crossing, according to surveys of that road.
Dayton, as above	0	725				

Scarcely any definite data concerning the amount of water flowing in the Miami river or its branches could be obtained. The Dayton Hydraulic Company relies upon Mad river for about 100 cubic feet per second in the driest part of an average year, an amount corresponding, for the 585 square miles of drainage area, to 0.17 cubic foot per second per square mile. July 3, 1867, during a tolerably low stage of water, Samuel Forrer, a prominent engineer of the state canals, gauged the Miami river at Dayton View, above Mad river, and found a discharge of 450 cubic feet per second. The drainage area above that point being 1,900 square miles, this discharge is equivalent to an average of 0.24 cubic foot per second per square mile.

The Miami and Erie canal, striking northerly from Cincinnati, reaches the immediate valley of the Miami river at Hamilton, then follows up the course of that river through its most important portion, and leaving it on the northern boundary of Miami county ascends the valley of Loramie's creek and passes over the summit-ridge into the Maumee basin. The first 66 miles of the canal above Cincinnati is supplied with water from the Miami and Mad rivers, the former being drawn upon near Middletown and Miamisburg, and the latter at Dayton. For the summit between the Miami and Maumee, and adjacent portions of the canal, reliance for a permanent supply is placed in a series of large reservoirs built and controlled by the state for that purpose. The principal of these are known, respectively, as the Saint Mary's or Mercer County, Loramie's, and Lewistown reservoirs. The Saint Mary's reservoir has elsewhere been alluded to as of remarkable size considering that it is entirely artificial, its surface covering an area stated by different authorities at 12,000 and 17,000 acres. As originally designed its flowage was 12,000 acres, its extreme length 10 miles, and its estimated storage when full over 4,000,000,000 cubic feet. It commands the drainage from about 200 square miles of territory.

From Piqua down to Dayton the course of the river is through the Devonian limestone, and the same cañon-like structure of valley is exhibited as along all the other streams running through that formation. Below Dayton

the valley is broad and open, flanked by low hills, between the bases of which the distance appears to be seldom less than a third or a half mile. The intervale is composed of level bottom-land, rich and largely cultivated for corn. The immediate banks vary considerably in height; at points they rise but a few feet above an ordinary stage of water, and again they range in height from 10 or 15 feet upward. While the river-bed is gravelly, the banks are of gravel and alluvial soil, the proportions of the two varying. The conditions are unfavorable to the building of dams of much height, unless at heavy outlay both for the structures themselves and for the flowage of land adjoining the river, or, if that is to be avoided, for its protection by dikes. On the other hand, the situation is well suited to long canals. At a moderate distance from the river the land becomes high enough to be above the reach of all ordinary freshets, and no rock-cuttings are necessary. In early days low rude dams were built here and there across the stream on shoals, and sufficient water was diverted into a little ditch to run, with the few feet of head obtained, some small grist- or saw-mills. As general manufacturing became introduced into this section, however, these privileges were purchased, one after another, the dams raised somewhat, and the canals extended so as not only to increase the head, but to convey the water to points where it could be utilized without danger of overflow from the river.

The principal places at which water-power is employed, from Dayton down stream, are, besides that city, Miamisburg, Franklin, Middletown, and Hamilton, at all of which water is conveyed through long canals ranging from 2 to 5 miles in length. The dams are of various construction—log, crib-work, framed work, and brush; the one at Franklin has a fall of 10 feet, claimed to be the highest on the river. At Franklin and Dayton View there is permanent power still open for lease, but at the other localities mentioned, although there is a surplus of water in some years, yet in others the supply falls short, and, so far as concerns reliable permanent power, those privileges are fully developed. Regarding a fair distribution of water to the various parties entitled to it, the conditions appeared much more satisfactory on this river than on most streams that were visited where there were many mills, the privileges here being as a rule controlled by joint-stock hydraulic companies, which attend to the proper maintenance of the works and division of the water. The latter is leased in so-called "runs" or "mill-stone powers", varying somewhat in size and price of rental at different localities, as shown below:

Rates charged by hydraulic companies for power at certain points in the Miami River valley.

Locality.	Company.	Equivalent of a run or mill-stone power.	Corresponding fall.	Theoretical power per run.	Established rental per run.	Rental per theoretical horse-power.	Remarks.
		Cubic feet per minute.	*Feet.*	*H. P.*			
Dayton	Cooper Hydraulic Company	315	12	7.16	$200±	$27 93	On Miami and Erie canal; rates vary between $150 and $300.
Do	Cooper Hydraulic Company (lower privilege)	400	8	6.06	150±	24 75	
Do	Dayton Hydraulic Company	233+	15	6.62	200	30 21	On Mad river.
Dayton View	Dayton View Hydraulic Company	300	12	6.81	250	36 71	On Miami river.
Franklin	Franklin Hydraulic Company	360	12	6.81	200	29 37	Do.
Middletown	Middletown Hydraulic Company	203+	18	6.01	200	28 94	Do.
Hamilton	Hamilton & Rossville Hydraulic Company	300	12	6.81	130–300	19 09–44 05	Do.
West Hamilton	West Hamilton Hydraulic Company	375	(?)	.....	200	.....	Do.

Of the 300 feet of fall in the Great Miami below Dayton to the junction with the Ohio river, there has been improved for water-power at Miamisburg about 21 feet, at Franklin 16½ feet, at Middletown from 15 to 18 feet, and at Hamilton 24 feet—a total of say 75 or 80 feet. Between Hamilton and the mouth the river is reported to be utilized for power by several small saw- and grist-mills, but through most of this distance it is without railroad facilities and was not visited. Probably the entire developed fall below Dayton does not exceed 90 or 100 feet. How much more might successfully be improved can be determined only by a detailed examination and survey, since the descent is not concentrated in falls and heavy rapids, but is distributed with comparative uniformity. Toward the Ohio the liability to trouble from the backwater of that river is of course to be considered. The Miami itself, like all the other streams of this section, is visited by heavy freshets, which rise above the low places in its banks, and at times even reach high ground, but no difficulty is experienced in finding safe locations for mills, and the trouble from backwater is not looked upon as serious. At Franklin an extreme freshet-rise does not reach a height of more than 12 or 14 feet above low water. Anchor-ice runs in the river more or less in winter, and at Hamilton it was stated that the surface is sometimes seen covered with it.

Power at Hamilton.—Hamilton is a city of 12,000 inhabitants, distant 25 miles from Cincinnati on the Cincinnati, Hamilton, and Dayton railroad, and is the first important site, ascending the river, where water-power is used. It is finely situated on level ground, well suited to carrying the canals and to the convenient location of mills. The river is here 300 or 350 feet wide between banks, and is utilized both on the east side in the city of Hamilton, and on the west bank at West Hamilton. The privilege on the east side is owned by the Hamilton and Rossville Hydraulic Company, and has been in continuous use for some thirty-five years. A low dam, not more than 3 or 4 feet high, and rudely built of brush and stone, diverts water into a canal in which it is brought down about 5 miles to the city. There the main canal extends some distance in a north-and-south direction, while a branch runs across

to the river-bank and follows that. Water is drawn from this level under three different falls: First, by mills discharging directly into the river and utilizing the full fall of 24 feet; second, a considerable portion is employed under a fall of 12 feet by mills discharging into a tail-race which runs parallel to the main canal, but in the opposite direction, extending up to an old channel of the river and there emptying; third, a part is also used under a fall of 7½ feet, and is then passed into a second level, the canal running over to the river, to which the water finally descends after being employed by mills under a fall of about 16 feet. Since quite an amount of water is returned to the river before having been utilized for the full available fall, it is evident that the entire power of the privilege is not realized.

The water-power at Hamilton is extensive, and is chiefly used by the following works: 4 large paper-mills, 3 or 4 machine-shops (one of them employing 300 hands), 3 flouring-mills, 1 woolen-mill, 2 manufactories of agricultural implements, 1 of saws, and others of plows, bran-dusters, chicken-coops, hubs, spokes, fellies, and various other articles in wood. Paper-making, machine-work, and flouring may be regarded as the principal industries.

Water is leased by the hydraulic company in mill-stone powers, a single one of which is defined as 300 cubic feet per minute with a fall of 12 feet. Its actual division is effected by delivering it over fixed iron weirs, so arranged that with a full canal each weir shall pass the amount to which the lessee is entitled. In January, 1883, there were in use 33 runs, or mill-stone powers, under 24 feet of fall, 14 under 16 feet, 42 under 12 feet, and 7 under 7½ feet. Most of the mills also have steam-power for use in low water. This is rendered necessary in some years, during the summer or fall, for periods ranging as high as six weeks and even two or three months. Some of the early leases on this privilege were made at $130 per annum per run, but the rental has been increased in more recent leases, and runs as high as $300. There are a few runs of nine months' water—liable to be shut off during three months of the year—but the rest stand all upon equal footing as respects rights to water during low stages of river. A deduction in rental is made for the time during which there is a shortage of water.

Backwater causes some trouble here during high freshets, and more or less hinderance is also experienced nearly every year owing to the temporary character of the dam. It rests upon a gravel bed, and being of the rude construction already alluded to is easily injured by ice or violent freshets, thus endangering the supply in the hydraulic canal. The latter varies in width, spreading out in places where the ground is favorable, and forming one large reservoir of about 100 acres and a second smaller one. For a mile from the dam, down to the large reservoir, the canal is quite uniform in size, designed, where in excavation, to be 30 feet wide at the bottom, with side-slopes of 1¾ to 1. In its extreme upper course it follows the river-bank, and is there exposed to washing of its own banks and even to submergence during unusual freshets.

On the west side of the river the privilege in use is owned by the West Hamilton Hydraulic Company. The dam is a log structure, located something over a mile up stream, and of course below the dam already described. The race supplies water to two flouring-mills, one saw-mill, and one furniture factory. The fall from the water-surface in the race to low water in the river is given as 16 feet, but a little of this is lost in a tail-race which runs by the mills and receives the water discharged from each. All these mills use overshot wheels, the largest stated to be 10 feet in diameter. Water is leased in runs, a run being defined as 375 cubic feet per minute, and presumably embracing the full available fall of the privilege; the rental charged is $200 per annum. This power has to depend for its supply of water upon what passes the upper dam and upon the discharge of Seven-Mile creek, which enters the Miami river between the two dams, and for about two months in the year there is a scarcity.

Power at Middletown.—Some 2 or 3 miles above the village is a state dam for diverting water to the Miami and Erie canal. In January, 1882, there was a heavy freshet in the Miami river, and the river-bed, which is composed of gravel at the site of the dam, was thought to have been washed away from beneath the structure so as to permit a settling which took place about 50 feet from the south abutment. The abutment itself next settled, and in February a breach occurred in the dam through which the entire volume of the river poured. The gap was closed by temporary brush-work, which, together with about one-third the old dam, was standing at the time this place was visited in the succeeding winter. It was designed, however, soon to replace the old structure by a framed dam.

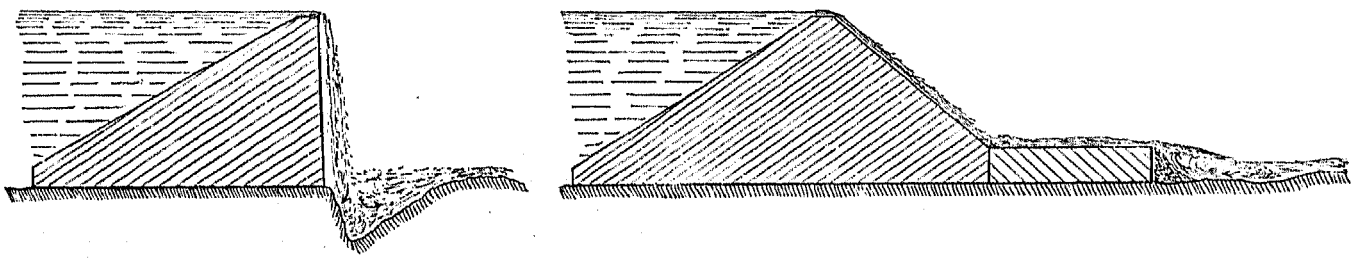
Of the water diverted by this dam a certain number of cubic feet is reserved by the state for feeding the Miami and Erie canal, while the balance, so far as needed, is conveyed through a hydraulic race, 2¾ miles long, to the village of Middletown, a place of 4,500 inhabitants, lying on the east bank of the stream. It is there utilized for power by five paper-mills, one flouring-mill, one machine-shop and pump-factory, and one planing-mill. Manila is the principal variety of paper manufactured, and the combined capacity of the mills is stated to be not less than 35 or 40 tons of paper per day.

The water-privilege is owned by the Middletown Hydraulic Company. Water is leased in mill-stone powers, the regular rental, from which there are few variations, being $200 per annum. The fall at the mills ranges from 15 to 18 feet, and the volume of water per mill-stone power varies correspondingly, but for a fall of 18 feet is defined as 203.22 cubic feet per minute. Water is measured out to the mills over fixed weirs. The hydraulic company reserves the right to a stoppage of supply for thirty days in the year, if necessary, and the volume flowing in the race is further liable to be more or less curtailed in summer or autumn by low water in the river, but allowance for such shortage is made in rental at the end of the year. It is said that the leases prescribe the use of overshot wheels, but in fact the majority, if not all, in use are turbines. If, by reason of a low stage of river, the supply of water becomes insufficient for the mills, these are shut off in order according to date of lease, the most recent first.

Up to January, 1883, about 95 mill-stone powers of water had been leased at Middletown, covering practically all the permanent power. In some years there is abundance of water throughout, but in others some scarcity, though even in extremely dry years the mills are fully supplied for nine months, and the hydraulic company is prepared still to lease power which may be relied upon for eight or nine months in the year.

Power at Franklin.—The dam at this point is about 600 feet long, with a fall from the crest of 10 feet in low water, and the hydraulic company has the right to raise it 3 feet. The actual height of the structure from foundation is much more than just stated, even reaching 30 feet in places where there has been scour and it has been necessary to fill in. The river-bed for not exceeding one-third its width at the site of the dam is rock, and the rest of the way sand and gravel. The original structure was called a "pole" dam and was built very much like a log dam, except of smaller timber not more than 5 or 6 inches thick at the butts. The breast did not, however, project far enough beyond the crest, the overpouring water produced heavy scour, and the dam was carried out. The volume of water flowing over in a heavy freshet is very great, and leaves but little difference of level above and below the dam.

The present structure has been built up as necessity required the renewal of old work—in 1874, '75, '76, and '81. In general terms, one-third is a log dam of the usual style, one-third a log and stone crib-work, and one-third of the old pole pattern. For the first, logs perhaps 50 feet long were employed, the requisite back slope being gained by cross-logs or binders placed in the breast, which was carried up as a series of offsets to serve as an apron. The spaces between the logs were filled in with stone. The crib-work portion of the dam has a tolerably long and regular slope each way from the crest. At the foot of the front slope is a crib-work apron 4 feet high, its farther extremity about 40 feet from the crest of the dam. Great importance is attached to this apron as preventing scour. When the

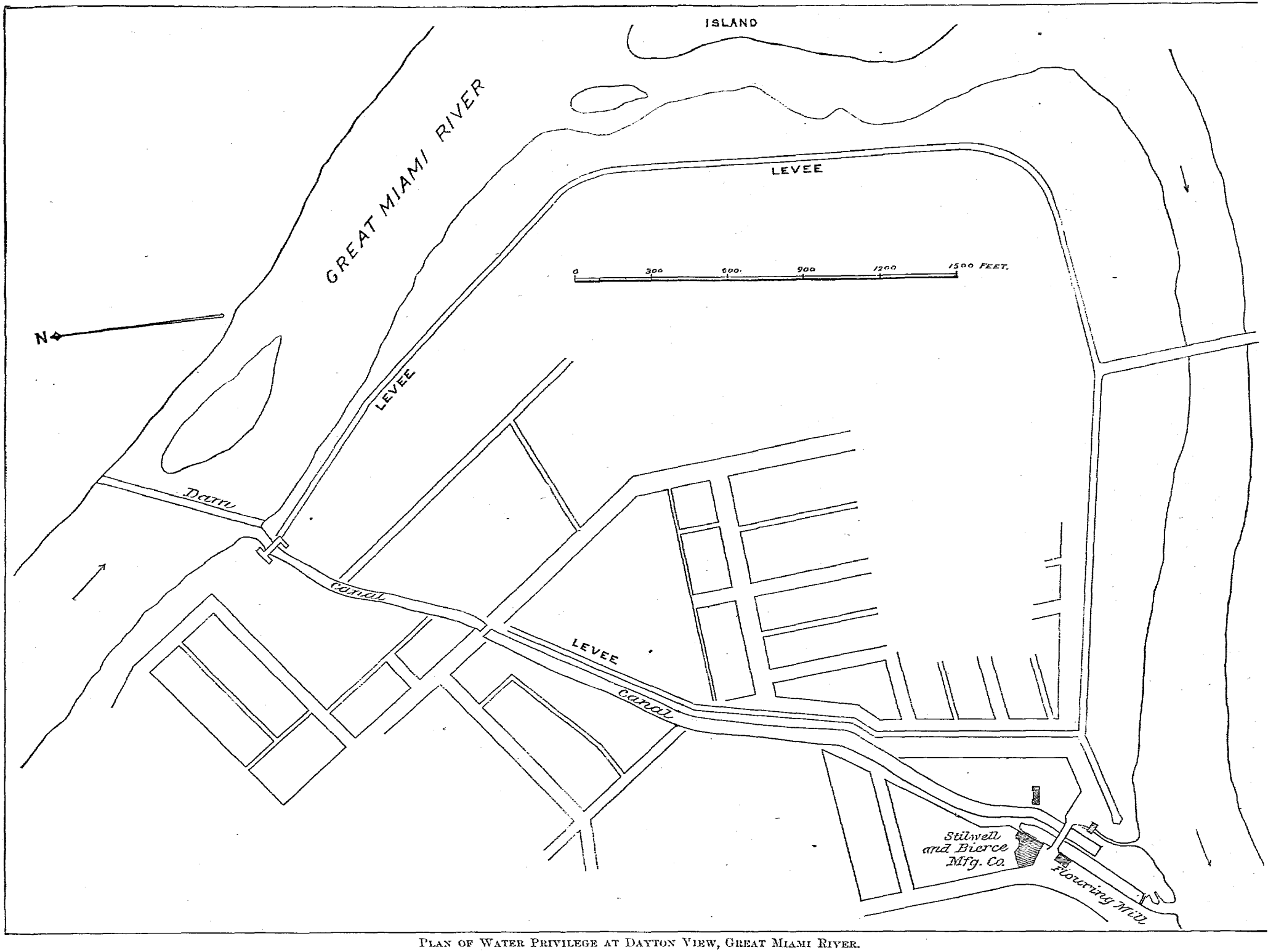


SKETCH SHOWING ACTION OF WATER IN PRODUCING SCOUR, AND CONSTRUCTION FOR AVOIDING IT.

breast of a dam has a steep slope (and in many cases it is built vertical), unless the river-bed below is of rock or receives artificial protection, it is certain to be worn out by the overfalling water and the safety of the dam to be threatened. If, however, the slope be reduced and supplemented by an apron, especially if the latter be given a slight upward pitch, the falling water is deflected forward and possibly even a little upward after leaving the apron, and thus appears to establish a return undercurrent, setting toward the end of the apron and tending to build up a deposit instead of scouring out the bed. It was stated by Mr. A. E. Harding, president of the hydraulic company, that by the action mentioned material has been filled in 20 feet deep at the foot of this dam, where during the life of the old structure a deep hole had been formed, and that in places it has even accumulated above the level of the top of the apron. There is no sheet-piling either above or below the Franklin dam. Neither here nor elsewhere on the Miami river does the pondage obtained appear to be of special importance, because of the general use of power by paper-mills which run night and day.

From the dam a hydraulic race is carried some 2 miles down the east side of the river to Franklin, its depth estimated at 6 or 7 feet, and its minimum width at 50 feet on the water-surface, while at many points it widens out considerably. The fall from the water-surface of the race at its foot to low water in the river is about 16½ feet. Power is in use by one writing- and one manila-paper mill, also by one planing- and one grist-mill. The Harding Paper Company manufactures fine writing-papers, and is said to be, with a single exception, the only concern engaged in that business in the West. The company occupies a handsome brick mill, and in January, 1883, had a capacity for producing 3 tons of paper per day; the works were also at that time being enlarged to a capacity of 6 tons per day. The company has another mill for the manufacture of fine writing-paper at Excello, on the Miami and Erie canal, where a fall of 10 feet is obtained around a lock.

The privilege which has been described is nominally owned by the Franklin Hydraulic Company, a joint-stock concern. The whole property is leased, however, for a period of twenty-eight years to the Harding Paper Company, which also controls a majority of the stock. A "run" or "mill-power" at Franklin is 300 cubic feet of water per minute under a fall of 12 feet, for which the established rental is $200 per annum. In January, 1883, seventy-eight runs were controlled under lease by the various mills and more or less completely utilized in manufacturing, and negotiations had nearly been completed for disposing of six more runs. The mills now in operation have abundance of water, and no measurements are made or weirs used. It is considered by the hydraulic company that in the average of years the privilege can be relied upon to furnish one hundred runs continuously, and a total of at least two hundred runs for ten months. The village of Franklin is attractively located, and had, in 1880, a population of 2,400. While no special inducements are held out, aside from the natural advantages of the place, other



PLAN OF WATER PRIVILEGE AT DAYTON VIEW, GREAT MIAMI RIVER.

manufacturing enterprises can obtain power here, and there is abundance of fine building-room. The Harding company owns twenty acres adjoining the lower course of the race, and this, together with five or ten acres more adjoining, is available for mill-sites. The theoretical power of this privilege may be estimated as follows:

Estimate of power at Franklin.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*10 feet fall.*	
Low water, dry year	10½	12	8½	9	40	2,710	330	37.5	600	280±
Low water, average year							430	48.8	780	
Available 10 months, average year							620	70.4	1,130	

Power at Miamisburg.—Miamisburg is a village of 1,900 inhabitants, 10 or 12 miles below Dayton, on the Cincinnati, Hamilton, and Dayton railroad. The Miami river is here from 250 to 350 feet wide between banks, and 2½ miles above the village is controlled by a dam—a framed structure 4½ feet high, resting on a gravel bed. The present dam was built about the year 1873, but the privilege was in use probably seventy-five years ago. From the dam, a hydraulic race, 40 feet wide at water-surface, runs about a mile and a half and then enters the Miami and Erie canal. By a contract with the state the Miamisburg Hydraulic Company, proprietor of the privilege, uses 1 mile of the state canal, and in return maintains repairs on that mile and furnishes water so far as needed for navigation. At the village of Miamisburg water for power is drawn by the mills directly from the state canal and discharged into the river. The extreme fall from the Miami and Erie canal to low water in the river is stated as about 21 feet, but the falls in actual use range from that figure down to 17 feet and even less. Power is utilized by the Ohio Paper Company and the Miami Valley Paper Company, manufacturers of book and news paper, with a combined capacity of 6 tons per day; also by a sash-and-blind shop and a flax-breaking mill. The permanent power of the privilege has all been leased, and the company is not prepared to dispose of any more rights to water at present.

Power at Dayton View.—Dayton View is on the right bank of the Miami, opposite the city of Dayton. The river here makes a bend about 2 miles in length, and across the neck a race has been carried to the mills, which are on the lower side of the bend. Stillwater creek enters the Miami not far above the dam, and Mad river empties between the dam and the tail-race. For fifty years there has been a dam on this privilege, at first a rude affair of brush and stone, but within a dozen years the hydraulic company has come into possession and done a large amount of work on the structure. At various times previously great quantites of bowlders, locally known as "nigger-heads", had been hauled on, and the company has itself added 3,000 perches. These bowlders weigh in many cases several hundred and even a thousand pounds each, and are obtained from the hilly ground adjoining the valley.

As reconstructed, the dam has a length of 650 feet and a fall from crest to low water in the river below of about 6½ feet. The natural bed of the stream is floored, so to speak, with the remains of the old dam for a distance with the current of perhaps 80 feet. Upon this foundation rests the dam proper, built of log cribs 12 feet square, all interstices carefully packed with bowlders and gravel. The main crib-work extends with the stream the length of two of these squares, or say 25 feet, and has an abrupt back slope, while the top has a long inclination down stream. Behind each series of transverse logs sheet-piling has been driven into the river-bed in double rows, breaking joints. This piling has a slant up stream, and against it is a mass of bowlders closely packed. The sheet-piling and logs, the plank covering of the dam and the logs, and the different courses of the logs themselves, are all firmly secured together by drift-spikes. Above the main structure is a heavy backing of loose stone. Below the dam transverse logs, planked over and having the spaces filled in with stone, form an apron projecting 16 feet down stream. The dam was at first left without any plank covering, but it was found that the action of ice-freshets was to force out the stone filling and threaten the security of the structure. Afterward the upper crib-work was covered with 3-inch planking, and then, successively, the lower crib-work and apron were covered, it being observed that in each case the bowlders were carried out from the portion left unprotected. The dam is now considered safe, durable, and tight.

A masonry bulkhead with head-gates has been built by the hydraulic company, at a cost of from $6,000 to $8,000, and admits water to the canal, which is about three-quarters of a mile long, designed with a width of 50 feet at water-surface and a water-depth of about 6 feet. Where this race reaches the vicinity of the river again are located the mills, power being utilized by the Stillwell & Bierce Manufacturing Company, manufacturer of turbine water-wheels; by A. A. Symonds, manufacturer of cutting-bar knives for paper-mills, planing and machine knives; and by C. B. Palmer & Co. for a flouring-mill. Between the dam and tail-race the river descends 4 or 5 feet, making the fall at the mills nearly or quite 11 feet, and by raising the dam 1 foot the hydraulic company claims that an available fall of 12 feet will be realized. This is, of course, subject to important reduction during high water, and in extreme freshets may be obliterated entirely; still, serious trouble from this source is not of long duration, the mills themselves are out of reach of high water, and the head-race and adjoining meadows are well protected by dikes.

The water-privilege is owned by the Dayton View Hydraulic Company, capital stock $75,000, which leases land and water to manufacturers for terms of ninety-nine years. A "run" is here defined as 300 cubic feet of water per minute under a fall of 12 feet, for which the regular rental is $250 per annum. The company is proprietor of 16 acres of land adjoining the lower part of the race, suitable for building-sites, and is desirous of leasing this, together with the remainder of its power. It assumes that with a fall of 12 feet it has forty-three permanent runs, and of these eleven had been leased by January, 1883. The site is without direct railroad facilities, but the haul for freights across the river to and from depots in the city of Dayton is not a long one, and there are convenient bridges.

Estimate of power at Dayton View.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 *foot fall.*	12 *feet fall.*	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year	10¼	12	8½	9	40	1,900	200	22.7	270	150±
Low water, average year							270	30.7	370	
Available 10 months, average year							420	47.7	570	

The examination of the main river did not extend above Dayton. According to the census enumerators' returns the use of power above that point is confined chiefly to small flouring- and saw-mills, with an occasional paper- or oil-mill, and may sufficiently well be learned from the table of utilized power.

Drainage areas of the Great Miami river and tributaries.

Stream and locality.	Drainage area.	Stream and locality.	Drainage area.
	Sq. miles.		*Sq. miles.*
Great Miami river at Piqua	890	Southwest branch at mouth	710
Great Miami river at Troy	950	Mad river near Springfield, above Lagonda creek	271
Great Miami river at Dayton, above Mad river	1,900	Lagonda creek at mouth	180
Great Miami river at Dayton, below Mad river	2,485	Mad river below junction with Lagonda creek	451
Great Miami river at Miamisburg	2,640	Mad river at mouth	585
Great Miami river at Franklin dam, 2 miles above village	2,710	Elk creek at mouth	347
Great Miami river at Middletown dam, 3 miles above village	3,080	Seven-Mile creek at mouth	307
Great Miami river at Hamilton dam, 5 miles above city and assumed to be above Seven-Mile creek	3,320	Whitewater river at Connersville	456
		Whitewater river at Brookville	1,217
Great Miami river at mouth	5,400	Whitewater river at mouth	1,482

Mad river, one of the most important tributaries of the Miami, which it joins at Dayton, has its source some 50 miles to the northeast of that city, in Logan county. Its drainage basin comprises 585 square miles. As has elsewhere been noticed, the river is characterized by a well-sustained flow, which is due to a great abundance of springs in the surrounding country and to the presence of extensive swampy tracts of land. It has in general a gravelly bed, and along its course are met the usual drift materials—gravel, clay, bowlders, and sand. At Snider's mill, near Springfield, rock appears, while at a bridge site not far below, a deposit of sand 40 feet deep is said to have been encountered. Other large deposits of sand occur in the vicinity, and it is the water leaching out from these which seems to have produced some of the "cat-head" swamps. From Dayton up nearly to Springfield the stream is bordered by low and wide flats or bottoms, beyond which, at a moderate elevation, is the rolling upland country. Not far west of Springfield, however, the valley narrows for a time and is flanked by rocky walls. The descent of the stream is tolerably rapid, amounting in about 21 miles above the mouth to 163 feet, an average of nearly 8 feet per mile. Many good water-privileges exist and are but partially utilized. Formerly there were numerous distilleries along Mad river, but within the past twenty years the industry they represented has greatly declined in this valley.

The largest use of power is at Dayton, a fine city of 37,000 inhabitants and an important manufacturing point. Water is drawn from Mad river some distance above the city, and above the dam by which the state diverts water for feeding the Miami and Erie canal. Some power has been in use on the privilege from the early part of the century, but the principal manufacturing at Dayton has developed since 1835, and the Dayton Hydraulic Company's works were constructed about ten years later. The dam has grown by accretions. It was originally built as a rough affair of timber, brush, and stone, rudely thrown up, but from time to time additions have been made of large bowlders, carefully packed, and in such manner as to give a somewhat regular shape to the dam, with a sloping face and apron. The interstices have been filled with gravel, and the sediment of the river has settled in and made the structure tight, so that in low water there is no leakage through it, though seepage takes place under it through the gravelly bed on which it rests. Although the dam is a substantial one, nevertheless after the severe winter of 1880–'81 a heavy run of ice carried away a part, making a breach perhaps 40 feet long. This portion was solidly

rebuilt, however, with timber, limbs of trees, brush, and bowlders, and is now considered to be as strong as any other part of the structure. In low water the fall from the crest to the river-surface below is about 7 feet.

The race extends about 2½ miles down to the city, and, with one exception, the mills are located at its extremity. This race is irregular in width, but is estimated to have ample capacity, when not obstructed by ice, for passing 10,000 cubic feet of water per minute; when frozen over its capacity is diminished at times to 8,000 cubic feet, and to even less in exceptional cases. Water is supplied for power to three flouring-mills, two paper-mills, two flax-mills, two plow manufactories, and one linseed-oil mill. The tail-water from these mills is discharged into the Miami and Erie canal. The hydraulic company has a contract with the state, by virtue of which it is entitled to discharge into the canal 10,000 cubic feet of water per minute, and as much more as necessary, provided no injury be done to the canal. The "head and fall" is reckoned at 15 feet, but is subject to slight variations from changes of level in head- and tail-race. The leases permit the use of overshot wheels of 13½ feet diameter, and that class of wheels is employed in all cases, except by the Meade Paper Company, the largest single user of power, this company having turbines. Water is drawn from the race through rectangular apertures between square-edged metallic plates, which are adjustable. The aperture is as close as convenient to the wheel, the width of opening being governed by the width of the wheel, for overshots, and the depth by the quantity of water to be supplied. As the level in the races varies, the aperture is correspondingly adjusted, and the power is maintained comparatively uniform.

A run of water is here fixed at 233⅓ cubic feet per minute, under a head and fall of 15 feet. There are assumed to be 26½ permanent runs, and for the average of a series of years the assumption is stated to prove quite accurate. In January, 1883, all these runs had been leased, and, in addition, 24 temporary runs, liable to be shut off in low water. The rate charged for permanent power is $200 per annum per run, and the same in proportion for temporary power. Throughout the year 1882 there was sufficient water for all the runs, both permanent and temporary, and a waste on the dam besides; while in 1881, for a time, not even all the permanent runs could be supplied. Both land and water are leased to the manufacturers by the hydraulic company.

Ascending above Dayton, power is utilized at short intervals along the course of the river, mainly by flouring-mills, of which there are 8 within perhaps 20 miles. These range in capacity from 150 barrels per day downward, and in connection with some of them are operated other small works such as corn-mills, saw-mills, and distilleries. A fall of 10 feet was reported to be in use by a paper-mill at Enon, and a few miles above Dayton a privilege with 14 feet of fall, owned by John Harries and formerly utilized by a flouring-mill, was found idle. These were the only powers on the section of river visited possessing as great a fall as 10 feet, the range at other points being only from 5 to 8 feet. Near Springfield the river is joined by Lagonda creek, which flows through that city and is taken advantage of for power by several manufacturing concerns, among them the firm of P. P. Mast & Co., extensive manufacturers of agricultural implements.

Above Lagonda creek the volume of Mad river is, of course, considerably smaller than toward the mouth, the tributary drainage area being less than one-half as great as at Dayton, but the stream continues to be employed for power at frequent intervals all the way to its headwaters, mainly by flouring-mills.

Table of utilized power on the Great Miami river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Great Miami river	Ohio river	Ohio	Hamilton	Flouring and grist	2	6	56		Cleves and Whitewater.
Do	do	do	do	Saw	2		38		
Do	do	do	do	do	1	4½	10		Cleves.
Do	do	do	do	Flouring and grist	1		20		
Do	do	do	do	do	1	5	30		Crosby.
Do	do	do	Butler	Flouring, grist, and saw	1	4	45		Ross.
Do	do	do	do	Agricultural implements	2	Total fall on privilege, about 24 feet.	15+	80	Hamilton and West Hamilton.
Do	do	do	do	Bread, crackers, etc	1		40		
Do	do	do	do	Blacksmithing	1		16		
Do	do	do	do	Carriage and wagon materials.	2		25	55	
Do	do	do	do	Flouring and grist	5		160		
Do	do	do	do	Furniture	1		12		
Do	do	do	do	Hardware	1		45		
Do	do	do	do	Machinery	3		60		
Do	do	do	do	Marble- and stone-works	1		30		
Do	do	do	do	Paper	4		208	250	
Do	do	do	do	Sashes, doors, and blinds	4		52	42	
Do	do	do	do	Saw	1		16		
Do	do	do	do	Wheelwrighting	1		16		
Do	do	do	do	Woolen	1		40	40	

Table of utilized power on the Great Miami river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Great Miami river	Ohio river	Ohio	Butler	Flouring and grist	1	15 to 18	90		Middletown.
Do	do	do	do	Lumber, planed	1				
Do	do	do	do	Machinery	2		16+		
Do	do	do	do	Paper	5		705+	690	
Do	do	do	do	Sundry articles in wood	(?)				
Do	do	do	Warren	Flouring and grist	1	16	22		Franklin.
Do	do	do	do	Lumber, planed	1		9		
Do	do	do	do	Paper	2		250±		
Do	do	do	Montgomery	Flax-beating	1	17–21			Miamisburg.
Do	do	do	do	Paper	2		110+	35	
Do	do	do	do	Sashes, doors, and blinds	1		12		
Do	do	do	do	Cutlery and edge-tools	1	10–11			Dayton View.
Do	do	do	do	Flouring and grist	1		150±		
Do	do	do	do	Turbines	1				
Do	do	do	Miami	Linseed oil	1	18–22	40		
Do	do	do	do	Paper	1		50		
Do	do	do	Shelby	Flouring and grist	2	20	76		
Do	do	do	do	Iron castings and finishings	1		16		
Do	do	do	Logan	Flouring and grist	3	10+	60		Miami and Pleasant townships.
Do	do	do	do	Saw	2		25		
Mad river	Great Miami river	do	Montgomery	Agricultural implements	2	13–15	500±	650	"Dayton" hydraulic canal.
Do	do	do	do	Flax, dressed	2				
Do	do	do	do	Flouring and grist	3				
Do	do	do	do	Linseed oil	1				
Do	do	do	do	Paper	2				
Do	do	do	do	Flouring and grist, etc	2	14	86		
Do	do	do	Greene	Flouring, grist, and saw	1	6	20		
Do	do	do	Clark	Paper	1	10			
Do	do	do	do	Flouring and grist	4	22	157		
Do	do	do	Champaign	do	2	18	55		
Do	do	do	do	Flouring, grist, and saw	2	19	100		
Do	do	do	Logan	Flouring and grist	3	54	108	60	
Tributaries	Mad river	do	Greene	do	1		20		
Do	do	do	Clark	do	8	150	273		
Do	do	do	do	Saw	2	33	32		
Do	do	do	do	Paper	1	9½	195	180	Possibly identical with a mill given on the main stream.
Do	do	do	do	Agricultural implements	1	24	100	85	
Do	do	do	do	Vegetable oil	1	40	30		
Do	do	do	Champaign	Flouring and grist	4	64	95	61	
Do	do	do	do	Woolen	1	18	12	30	
Do	do	do	Logan	Flouring and grist	1	21	80		
Whitewater river	Great Miami river	do	Hamilton	do	1	7	45		
Do	do	Indiana	Dearborn	do	4	24	170	100	
Do	do	do	Franklin	do	1	16	25		
Do	do	do	do	Machinery	1	12	3		
Do	do	do	do	Paper	1	15	150	100	
Do	do	do	do	Saw	1	8	38		
Do	do	do	Fayette	Coffins	1	17	20	16	
Do	do	do	do	Flouring and grist	3	46	95		
Do	do	do	do	Furniture	1	25	35	45	
Do	do	do	do	Machinery	1	20	15		
Do	do	do	do	Saw	1	8	15		
Do	do	do	Wayne	Cider	1	14	10		
Do	do	do	do	Flax, dressed	1	9	17		
Do	do	do	do	Flouring and grist	8	124½	301	100	
Do	do	do	do	Linseed oil	1	14	22	22	
Do	do	do	do	Paper	1	8	39	55	
Do	do	do	do	Pianos	1	12	40		
Do	do	do	do	Saw	1	11	40		
Tributaries	Whitewater river	do	do	do	6	54½	93		
Do	do	do	do	Machinery	1	17	45		
Do	do	do	do	Woolen	3	45	45	5	
Do	do	do	do	Flouring and grist	17	280+	575	20	
Do	do	do	Union	do	5	40	85	24	
Do	do	do	do	Saw	1	18	25		
Do	do	do	Franklin	Flouring and grist	7	74+	200		

Table of utilized power on the Great Miami river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Tributaries	Whitewater river.	Indiana	Fayette	Pumps	1	7	5	.....	
Do	....do	....do	....do	Saw	1	10	10	.....	
Do	....do	Ohio	Preble	....do	1	13	10	.....	
Do	....do	....do	....do	Flouring and grist	2	20	35	.....	
Sundry small streams	Great Miami river	....do	Butler	....do	9	95+	352	.....	
Do	....do	....do	....do	Saw	4	41	90	.....	
Do	....do	....do	Warren	Woolen	1	2	12	.....	
Do	....do	....do	....do	Flouring and grist	6	107	112	.....	
Do	....do	....do	Montgomery	....do	13	200½	373	.....	
Do	....do	....do	....do	Saw	7	115	102	12	
Do	....do	....do	Preble	....do	4	31+	92	.....	
Do	....do	....do	....do	Woolen	2	67	22	.....	
Do	....do	....do	....do	Flouring and grist	11	139	262	175	
Do	....do	....do	Darke	....do	5	58	104	.....	
Do	....do	....do	....do	Saw	1	5	10	.....	
Do	....do	....do	....do	Woolen	1	12	18	.....	
Do	....do	....do	Miami	Flouring and grist	14	198	533	25	
Do	....do	....do	....do	Saw	5	59	103	.....	
Do	....do	....do	....do	Woolen	6	105+	72	.....	
Do	....do	....do	Clark	Saw	3	28+	92	.....	
Do	....do	....do	Champaign	Flouring and grist	1	25	12	.....	
Do	....do	....do	Logan	....do	8	144	180	12	
Do	....do	....do	....do	Saw	2	23	50	.....	
Do	....do	....do	Shelby	Flouring and grist	3	50½	70	.....	

Table of utilized power on various minor tributaries of the Ohio river (above the mouth of the Miami river on the north, and above the mouth of the Little Kanawha river on the south).

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Little Beaver river and tributaries	Ohio river	Ohio	Columbiana	Flouring and grist	14	187	377	60
Do	....do	....do	....do	Saw	2	12+	31	.....
Do	....do	....do	....do	Woolen	1	10	6	6
Hocking river and tributaries	....do	....do	Athens	....do	1	7	20	.....
Do	....do	....do	....do	Flouring and grist	6	41	258	.....
Do	....do	....do	Hocking	....do	3	21	60	.....
Do	....do	....do	....do	Saw	1	8	20	.....
Do	....do	....do	Perry	Wheelwrighting	1	14	4	.....
Do	....do	....do	Fairfield	Flouring and grist	6	84	80	.....
Little Miami river and tributaries	....do	....do	Hamilton	....do	3	16	124	.....
Do	....do	....do	Clermont	....do	6	71	154	.....
Do	....do	....do	Warren	....do	10	81½	399	.....
Do	....do	....do	....do	Gunpowder	1	5	100	.....
Do	....do	....do	....do	Saw	6	40½	200	.....
Do	....do	....do	Greene	Flouring and grist	15	192½	477	70
Do	....do	....do	....do	Gunpowder	1	0	120	200
Do	....do	....do	....do	Paper	1	20	55	50
Do	....do	....do	....do	Saw	9	53	210	10
Do	....do	....do	Brown	Flouring and grist	1	7	8	26
Do	....do	....do	Highland	....do	1	7	10	8
Do	....do	....do	Clinton	....do	4	44	73	50
Do	....do	....do	....do	Furniture	1	10	20	.....
Sundry small streams	....do	....do	Clermont	Flouring and grist	1	20	20	25
Do	....do	....do	Brown	....do	11	158+	251	150
Do	....do	....do	Adams	Flouring and grist	8	143	130	138
Do	....do	....do	....do	Saw	2	27	30	40
Do	....do	....do	Scioto	....do	3	24	64	.....
Do	....do	....do	....do	Flouring and grist	3	24	147	.....
Do	....do	....do	Lawrence	....do	6	46	146	.....

Table of utilized power on various minor tributaries of the Ohio river, etc.—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Sundry small streams	Ohio river	Ohio	Lawrence	Saw	1	7	8	.....
Do	do	do	Gallia	do	3	10	60	.....
Do	do	do	do	Woolen	2	18	33	.....
Do	do	do	do	Flouring and grist	10	63	211	.....
Do	do	do	Jackson	Flouring, grist, and saw	1	8	32	.....
Do	do	do	Vinton	Saw	5	44	75	.....
Do	do	do	do	Flouring and grist	7	57½	223	.....
Do	do	do	Meigs	do	7	58+	190	.....
Do	do	do	do	Saw	3	16+	58	.....
Do	do	do	do	Tannery	1	16	14	.....
Do	do	do	Washington	Flouring and grist	6	40	138	.....
Do	do	do	Noble	do	2	14	35	30
Do	do	do	do	Saw	1	6	20	.....
Do	do	do	Monroe	do	2	30	31	16
Do	do	do	do	Flouring and grist	17	163	424	65
Do	do	do	Belmont	do	11	143	236	30
Do	do	do	do	Woolen	1	8	10	.....
Do	do	do	Harrison	Saw	1	24	25	.....
Do	do	do	do	Flouring and grist	6	82	145	84
Do	do	do	Jefferson	do	9	112	158	30
Do	do	do	Columbiana	do	3	50	95	.....
Do	do	Pennsylvania	Beaver	do	1	8	16	.....
Do	do	do	Butler	do	1	9	30	24
Do	do	do	Allegheny	do	1	15	12	12
Do	do	do	do	Hosiery	1	15	8	.....
Do	do	do	do	Flouring and grist	3	32	41	48
Do	do	do	Beaver	do	8	108	137	105
Do	do	do	do	Saw	1	10	15	.....
Do	do	do	Washington	do	4	30	111	30
Do	do	do	do	Flouring and grist	21	215+	482	330
Do	do	do	Greene	do	4	30	122	174
Do	do	West Virginia	Hancock	do	4	50	108	65
Do	do	do	Brooke	do	6	85	141	90
Do	do	do	Ohio	do	5	65	90	30
Do	do	do	Marshall	do	8	83	132	20
Do	do	do	do	Saw	2	32	50	.....
Do	do	do	do	Tannery	1	.....	8	8
Do	do	do	Wetzel	Saw	5	40	150	.....
Do	do	do	do	Flouring and grist	8	67	150	30
Do	do	do	Tyler	do	10	60½	248	.....
Do	do	do	do	Saw	3	20	60	.....
Do	do	do	Pleasant	do	3	.....	60	40
Do	do	do	do	Flouring and grist	3	15+	46	20

WATER-POWER

OF THE

OHIO STATE CANALS.

489—57

WATER-POWER OF THE OHIO STATE CANALS.

Although the writer's examination of water-power in Ohio was limited to that part of the state draining southerly toward the Ohio river, while the principal canals cross not only that portion but also the northern slope, nevertheless it may be proper to give in this report some facts regarding the canal system as a whole. Accurate and detailed data concerning the canals are so scattered among various reports, stretching back over a period of fifty years,(a) and upon some points are so entirely lacking, that the most to be attempted will be to convey a general idea as to the history, present condition, value for power, and extent of utilization of these artificial water-ways.

The state canals were constructed in the neighborhood of 1830, and were designed chiefly to afford convenient and cheap communication from the interior of the state to the Ohio river on the south and to lake Erie on the north, and thus to command access to various distant markets. The Ohio canal across the eastern and central portion of the state, and the Miami, connecting with the Wabash and Erie and forming a north-and-south line through the western counties, were the most important of these routes. By the construction of the Hocking canal, the Walhonding, and other minor branches, and by the improvement of the Muskingum river, the system of water-transportation was considerably extended. The numerous state reports belonging to the period of canal construction bear abundant evidence as to the prominent place which these enterprises then held in the public mind; nor, judging from the later history of this great commonwealth, can there be any doubt of the valuable part which they have played in its development. But the position which the canals occupied when they first came into general use has undergone a great relative change. From the condition of being leading highways of traffic, and chief factors in internal growth, they have sunk to that of partial competitors, and to some extent regulators, in the general traffic of the state, heavily handicapped at the same time through certain inherent disadvantages, and in public estimation have come to be judged worthy of only a half-hearted support at the best, and frequently of contempt and neglect.

Some of the small branch canals have never proved profitable, and have from time to time been abandoned, no doubt wisely. The original northern termini of both the Ohio and the Miami and Erie canals have been given up and granted, the former to the city of Cleveland and the latter to Toledo. The southern terminus of the Miami and Erie canal has been cut off for three-quarters of a mile from the Ohio river and granted to Cincinnati, thus severing connection with the river and entailing extra expense upon the transfer of freight from one to the other. The southern outlet of the Ohio canal, also, though nominally open, was practically closed at the time it was visited in January, 1883, by a ruined lock.

Fifty years ago Ohio was a heavily-timbered state, the streams were running fuller than they now do, and the supplying of water to the canals was an easier matter than it has been in late years. To insure sufficient water during the dry seasons, reservoirs, some of them of remarkable size, were constructed in different parts of the state, adjacent to the summit-levels of the canals. With the settlement of the country, its clearing, and more general artificial drainage, the streams have become more uneven in flow than they were before, and the demands upon the reservoirs threaten in some cases to exceed their power to respond. The Licking reservoir, of 3,300 acres, has proven insufficient for the needs of that part of the Ohio canal dependent upon it, and for two months in some years continuous navigation of the latter is impracticable, and lightering has to be resorted to. Even upon the water readily at command a serious and wasteful draught must be made by leaky dams, aqueducts, and locks, in the present inferior condition of the canal works.

When the water-ways we are considering were constructed, there was no thought of railroads as coming competitors. The state was desirous of leasing her surplus waters for power, and did so at what now seem very low rates, usually for periods of ninety-nine years, supposing that by encouraging the location of mills along the canals the business of the latter would thereby be increased. But by the introduction of railroads the routes for shipment have changed, and lessees are enjoying water-privileges at low rates, while the canals do not reap corresponding benefit. Leases of new powers are being issued from time to time, and occasionally some old lease is vacated; in all such cases the state endeavors to obtain new rates that shall be more favorable to her. The total

a Those figures and statements which will hereafter be given are in many instances taken from such sources, and would perhaps require some revision in order to serve for an exact description at the present time; but in the main they are thought to be reliable.

annual rentals received by the state of Ohio on water-power leases are between $50,000 and $60,000, the distribution of which among the different canals, as well as the relation of the income thus derived to that from transportation, may be seen in the following table:

Statement of tolls and fines and water-rents received by the state of Ohio from canals during the year ending November 15, 1880.

[From *Annual Report of Board of Public Works.*]

Name of canal.	Tolls and fines.	Water-rents.
Miami and Erie	$73,061 64	$38,198 03
Ohio	68,703 99	8,841 67
Muskingum improvement (slack-water on Muskingum river)	13,066 93	5,508 65
Hocking	6,489 98	080 47
Walhonding	380 29	
Total income from sources mentioned	162,302 83	53,588 82

The leases under which water-rights are enjoyed are variously made out to cover, in some cases, the surplus flowing around a certain lock; in others, water sufficient for a certain number of runs of stones; and, again, a specified number of cubic feet per minute. No suitable means are in use for a measurement, even tolerably approximate, of the amounts of water actually taken by lessees; there is every reason to suppose that they are in many instances largely in excess of the lawful dues, and disputes are frequent. The state reserves a right in all cases to shut off water from lessees for a period of 30 days in the year for the purpose of making repairs to the canals; and also the right of resuming at any time the use of water previously granted or leased, when it shall appear necessary to the interests of navigation, but in the latter instance must compensate the purchaser or lessee.

There are strong reasons for doubting the wisdom of maintaining a system of lease and sale of water-rights in connection with the canals, if these are to be used the most efficiently for navigation. But since the state of Ohio has become so far committed to such a method, it is natural to notice, in the next place, the real value of the powers which thus become available for manufacturing. The power of a privilege is, of course, governed by the amount of water at command and the height of fall through which it can be used. And because, in general, along the canals of Ohio the surplus of water is not very great, nor the fall to be obtained around locks very large, it follows that the powers resulting are to be reckoned for general manufacturing-purposes as only moderate in size, the actual effective powers in use on the Miami and Erie canal averaging about 50 horse-power each, though ranging from 10 to 300, and those on the Ohio canal averaging about 35 horse-power each, with a range from 10 to 150. Those scattered at random along the lines of the canals are suited to flouring-mills of ordinary size, while at a few exceptional points, such as Cincinnati, Dayton, and others, chiefly on the Miami and Erie canal, sufficient power is obtained to support manufacturing of considerable importance.

The main trunks of the Ohio and the Miami and Erie canals were built with a minimum breadth of 40 feet at the water-line and 26 feet at the bottom, with a water-depth of 4 feet. A great part of both canals is of much larger dimensions, having a breadth at water-line of from 60 to 150 feet, and a depth of from 5 to 12 feet, while in some localities even these figures are exceeded. Portions of the canals, however, have become silted up, and their capacity for carrying water has become diminished not only in that way, but also by a thick growth of grass which chokes the channel in summer. The true character of the canals should be kept in mind—that of artificial water-courses, through which there is a slow movement of water toward the points of lowest depression, the supply being introduced at intervals along the course from neighboring streams or reservoirs in order to make up for the losses which are constantly going on through leakage and evaporation, as well as to meet the demands of lockage from one level to another.(*a*)

A greater surplus will evidently be available for power in those portions of the canals below and adjacent to feeders, than farther along where the flow has become so reduced as to need replenishing. The value of the canal powers must depend upon their reliability through the year as well as upon their size. As has been said, they are liable to be cut off thirty days in the year by the state for repairs; they also suffer at many points from diminished flow in summer, when the feeders are low and the channels are choked by grass, and in winter when the water-way is contracted by thick surface-ice or gorged by broken masses. Of the water diverted toward and into the canals much is wasted owing to the leaky condition of the various structures. Nevertheless, it is to be said in favor of canal-privileges that they are usually safe from all danger of freshets, involve no outlay to the users for dams, and offer conveniences for transportation; so that, notwithstanding certain disadvantages, they have important value, and it is not to be wondered at that under the low rentals charged in Ohio they have been very generally occupied for manufacturing-purposes. Although the most desirable powers are already in employment, the state yet holds numerous others, both on the canals and at the dams on the Muskingum improvement, suited to use.

a It was originally estimated that for the Ohio canal, at least, there would be required 100 cubic feet of water per minute per mile, and the maximum velocity of current was placed at 1 foot per second. No accurate data are at hand, however, as to the amounts really furnished or required.

Though it was found practicable to visit but a few of the many privileges utilized along the Ohio and the Miami and Erie canals, a brief description of those examined will perhaps be useful in illustrating what has already been said. The general distribution of the various powers may be learned from the tables elsewhere given, compiled from the census enumerators' returns.

THE OHIO CANAL.

This canal has a length of 309 miles, extending from Cleveland on lake Erie, to Portsmouth on the Ohio river. From the former city it ascends the valleys of the Cuyahoga and Little Cuyahoga rivers, and reaches the north end of the summit-level at Akron, 38 miles from Cleveland. This portion is fed mainly from the Cuyahoga and Little Cuyahoga rivers, and has an ascent of 395½ feet, overcome by means of 44 locks.(a) Of these, 21 are within 3 miles, and 16 within 1½ mile of the north end of the summit-level at Akron. Power is utilized by a number of mills, principally at the last-mentioned place.

The canal now enters the basin of the Tuscarawas river, and from the south end of what is known as the Portage summit-level has an uninterrupted descent to Websport, following the Tuscarawas valley and then that of the main Muskingum river. In this distance of 112 miles there is a fall of 238.6 feet, effected by 29 locks. The low level at Websport is also at the foot of a continuous descent from the Licking summit, which lies to the westward, the surplus waters entering it from either direction being discharged through a side-cut into the Muskingum river at Dresden. On the division extending from the Portage summit to Websport and Dresden there are nearly a dozen flouring-mills, using various powers, ranging usually between 15 and 50 horse-power, but in two or three cases reaching 100 and 150. Of these there was visited only the one at Lockport, opposite New Philadelphia, where power is utilized under a fall of 12 feet around a lock at Patterson & Hardy's flouring-mill. Water is taken from above the lock, discharged into the level below, and at times in summer is insufficient for the needs of the mill, which has a capacity for producing 40 barrels of flour daily. For supplying this portion of the canal the Tuscarawas river is drawn upon at Clinton, Zoar, and near the mouth of Stillwater creek; the Walhonding river is drawn upon a few miles above Roscoe, and several minor tributaries of the Tuscarawas also assist.

From the low level at Websport the canal rises to the westward to the Licking summit, making an ascent of 160 feet in the 42 miles by means of 19 locks. The water-supply is derived from the Licking river at the "Narrows", from one or two forks of the main river, and from the Licking reservoir. There are no returns indicating any present use of power on this section of the canal. At Newark there is a fall of 18 feet from the feeder and from the main canal to the water-surface in the North fork of the Licking river, but it is not utilized. In years past the feeder has been employed at Newark for a small woolen-mill, a flouring-mill, and a saw-mill, which did quite an extensive business, but they have one after another abandoned the use of the water-power, the flouring-mill within two or three years, though enjoying at the last exclusive use of the water. The feeder at that point draws from the North fork, and should take its entire low flow; but the feeder-dam is reported as leaky, and the canal has been allowed to silt up, thereby diminishing its capacity, so that the available flow of the stream is not utilized.

From Licking summit the canal runs westerly down the valley of Walnut creek, a tributary of the Scioto river, descending 202¼ feet by means of 30 locks in the 30 miles before it reaches Lockbourne. It receives water in this part of its course from the Licking reservoir, from Little Walnut creek, and from one or two other small streams, and by the Columbus feeder is re-enforced from the Scioto river, which is drawn upon at the above-mentioned city, the feeder running thence southerly about 12 miles, to Lockbourne, with a fall of 14 feet. Several flouring-mills obtain small powers from this section of the Ohio canal, but upon any portion largely dependent upon the Licking summit the supply of water for power must be unreliable.

From Lockbourne the canal takes a southerly direction and continues down the valley of the Scioto river to Portsmouth, at its mouth. In this distance of 87 miles there are 24 locks, and a descent of 211 feet to low water in the Ohio river. The demands of lockage and waste are met by drawing upon the river 2 miles below Circleville, and again 6 miles below Chillicothe. There are small powers in use on this division of the canal by half a dozen or more flouring-mills, two of which will be noticed:

A mile or so above the city Marfield & Massie obtain about 14 feet of fall around two locks. They have the surplus waters from the canal, to which they are limited by a weir built at the entrance of their race to within a few inches of the ordinary water-surface in the canal. The locks are leaky, however, and the firm estimates that *half as much water is thus lost as it uses. The mill is a fine one, with twenty-eight sets of rollers and an* ordinary capacity for producing 400 barrels of flour in twenty-four hours. This part of the canal is supplied from the Circleville feeder, some 18 miles above, and trouble is experienced in summer from the obstruction of the channel by grass, and in winter from ice. The mill has two overshot wheels, each considered to be of about 20 horse-power with abundant water, but the proprietors estimate that they actually get not over 25 horse-power from the two together, and that for only one-third of the year. Reliance for the balance of the power needed is placed in a steam-engine.

Near the southern terminus of the canal, and about 1½ mile from Portsmouth, George Davis & Co. carry water in a side-cut past two locks and obtain a fall of perhaps 15 feet. They employ a 14-foot wooden

a The locks on the Ohio canal are about 90 by 15 feet in size.

overshot wheel, 12 feet wide, and operate four runs of 4-foot stones, and one double set of rollers. They run their mill twelve hours per day, its capacity being about 50 barrels of flour in that time. Water is drawn from a 6-mile level, and the firm considers the power good for about half the year. From June to September the grass which grows in the canal obstructs the flow of water, and resort is then had to steam-power. In extremely cold weather 8 inches of ice sometimes forms in the canal, and to a considerable extent lessens the flow. At such times the side-cut is liable to become drawn down, the surface-ice in it sinks, and when the water-level rises again the water overruns the ice and freezes; so that when there is 8 inches of ice in the main canal there may be twice that thickness in the side-cut, and the flow is correspondingly interfered with. The wheel also at times becomes covered with a mass of ice which hinders its working.

THE MIAMI AND ERIE CANAL.

This is the most important of the existing canals in Ohio, both with regard to navigation and to use for water-power. From Cincinnati it extends northerly, at a distance ranging from 15 to 35 miles from the western boundary of the state, into Defiance county, where it turns northeasterly and follows down the Maumee river to Toledo. The main trunk has a length of about 246 miles. It originally entered the Ohio river at Cincinnati, and the Maumee river close to its mouth several miles below Toledo; but, as we have elsewhere seen, these termini have been cut off. The section traversed by the canal is fertile, thickly settled, wealthy, enjoys abundant railroad facilities, and has an established character as a manufacturing district. The structures on the Miami and Erie canal appear to be in better condition than those on the Ohio canal, and the hydraulic powers are favored by a generally copious supply of water, derived from the Miami and Maumee rivers and from a system of large reservoirs in the summit-region between their basins. The water-powers along the whole line of the canal are quite generally taken up and in use; this is especially true between Dayton and Cincinnati, and it was stated that probably no more power would be leased along that portion, from danger of interfering with the interests of navigation. The manufacture of flour is an important interest along the entire canal and stands first as regards the number of mills. The paper industry ranks next in this respect, and has been most developed between Dayton and Cincinnati. There are small woolen-mills, also, at various points, as well as saw-mills, machine-shops, agricultural-implement factories, oil-mills, and other works. The greatest utilization of power is found among the three southern counties of Hamilton, Butler, and Montgomery, and in the middle and northern counties of Miami, Auglaize, and Lucas.

At Maumee city, some 8 miles above Toledo, the canal is 63 feet above the level of the Maumee river and lake Erie, and is connected with the former by locks. From this point for 15½ miles, up to the head of the rapids, where the Maumee is rendered tributary for feeding the levels below, there is no lockage. When the canal was built the question of water-power in connection with it was considered, and in the *Sixth Annual Report of the Board of Public Works* (1843), it was stated that "the capacity of this canal is such that from the head of the rapids to Manhattan 18,000 cubic feet of water per minute can be passed and used for hydraulic purposes, without injury to the navigation. At Maumee city the water can be used over a fall of 63 feet; at the locks above Toledo the water can be used over a fall of 49 feet, and at Manhattan over a fall of 15 feet; and between these points the canal is so located that the water can be used from it for hydraulic purposes with great convenience, occupying all the fall between the canal and river". An important amount of power is now in use from this portion of the canal by several paper-mills and large flouring-mills.

From the pool above the rapids the succeeding 26 miles of canal, to Independence, is supplied from the river by means of a dam at that place 9 feet high. From the long level below Independence the report already quoted from mentions an opportunity to utilize a fall of 23 feet to the river. The portion of canal we are now considering was originally known as the Wabash and Erie, being continuous with the Indiana canal of that name. From its junction with the old Miami canal in Paulding county, to the outlet at Toledo on the level of lake Erie, a distance of 64 miles, there is a total descent of 148 feet, effected through 19 locks. This section of the canal was constructed 60 feet wide at top water-line and 6 feet deep. From Paulding county the canal takes a quite direct southerly course, and thence to Dayton, 113 miles below the junction, is utilized at frequent intervals for power by flouring-mills, and occasionally by small woolen factories, saw-mills, and other works, though no details concerning them are at hand other than those furnished by the census enumerators' returns.

At Dayton considerable power is in use on the canal by the Cooper Hydraulic Company. In connection with Mad river the Dayton Hydraulic Company's privilege has already been described, and it has been stated that the water taken by that concern from the river is discharged, after passing through the mills, into the Miami and Erie canal. From the basin into which it is thus discharged it is withdrawn by the Cooper company and utilized under a fall of 12 feet around a lock, being then returned to the canal. At a point below, a certain amount is again withdrawn from the canal, and after it has been employed for power under a fall of 8 feet is discharged into the Miami river. The hydraulic company owns a part of the water, acquired by purchase, and also leases from the state, at an annual rental of $1,000, all the surplus running to supply the levels below Dayton. On this privilege a "run" is defined as 315 cubic feet of water per minute on the "middle", as it is called, or 12-foot fall, and 400 cubic feet per minute on the "lower" or 8-foot fall. A run at the middle fall was originally 300 cubic feet, but, in

consequence of slight backwater, was increased to 315 cubic feet. The rates for both temporary and permanent power vary from $150 to $300 per annum per run, but the larger portion is leased at $200 per annum on the middle and $150 on the lower fall. Water is drawn into the mills through fixed apertures, and is utilized by 4 flouring- and grist-mills, 2 oil-mills, 2 machine-shops, 2 manufactories of agricultural implements, 1 cotton factory, 1 establishment for pulverizing stone, and some other works of small size. One of the lessees has the right to all surplus waters on the privilege, so that the hydraulic company has no more power of which to dispose.

From the basin at Dayton to low water in the Ohio river at Cincinnati, a distance of 66 miles, the canal descends about 300 feet, through 32 locks. Water for feeding the various levels south of Dayton is introduced at that city, Miamisburg, and Middletown. The manufacturing along this section is extensive, the paper and flouring industries being especially prominent. For the former of these as now developed, however, the power furnished from the canal alone is not sufficiently reliable, and the mills are generally fitted with steam-engines for use when the water-supply runs short. Only a few privileges can be noticed in detail:

At Carrollton, 7 or 8 miles below Dayton, George H. Friend & Son have three mills for the manufacture of news, book, manila, and express paper, the aggregate production being from 10 to 15 tons per day. They obtain a fall of 16 feet, and have two water-wheels, each of about 40 horse-power, but generally there is enough water for only one wheel; they operate five steam-engines, and regard steam as their principal motive power. The privilege at this point is considered to have been much better formerly, but is said to have deteriorated through the silting up of the canal and the obstruction of its channel by grass.

At Hamilton, P. Carle & Co. use the surplus passing around a lock, under a fall of 6 feet, to furnish power for their flouring-mill, in which are six sets of rollers. They have water-wheels rated at an aggregate of 100 horse-power, and claim to have sufficient water always, except when it is shut off by the state for repairs.

At Lockland, 12 miles by railroad to the north of Cincinnati, water is taken from a 6-mile level in two races and supplied to mills, which discharge it into the canal again after use. Log weirs prevent the canal-level from being drawn more than 6 inches below its ordinary height. When the canal was built it was considered that there could be spared at this point for hydraulic purposes water sufficient for 12½ runs of stones, and this was divided into three nearly equal parts and leased. The east race runs to a grist-mill. The west race first supplies two paper-mills, one of them owned by the Haldeman Paper Company, under a fall of 14 feet. A fall of 10 feet is then used by the Friend & Fox Paper Company in its printing-paper mill, and from the same level a little surplus is drawn for a small grist-mill. Half a mile farther down the canal the Haldeman company has a second mill. This company manufactures roofing-felt, and various kinds of coarse wrapping-paper, and in addition to rags uses probably 3,000 tons yearly of straw. The latter material is largely employed throughout the Miami valley in paper-manufacture, and, being very extensively produced, is cheaply obtained. For considerable periods it has been purchased at Lockland at as low as $3 per ton, and it was stated by a prominent manufacturer that the average price for a series of years throughout this section was probably about $6 per ton. At Lockland the Haldeman company uses a 61 horse-power water-wheel, but for about three months in winter there is more or less shortage in the supply of water, owing to ice in the canal and race. It forms thick enough to diminish the volume of flow, and this is still further lessened by the breaking up of the ice by boats and its formation in gorges. Water is regarded by the company as its principal power in general, but steam is relied upon at times when the canal supply is insufficient. There was said to be no trouble in this vicinity from grass growing in the canal.

Of the entire rentals received by the state of Ohio from water-leases, about $38,000, or 70 per cent., is derived from those on the Miami and Erie canal, and of this sum nearly $15,000 is paid at Cincinnati. More in detail, fourteen firms and companies north of Brighton pay at Cincinnati $6,193, and seventeen south of Brighton, $8,516.(a) The six largest lessees of power, engaged variously in the manufacture of paper, flour, cotton, and oil, pay rentals ranging from $2,200 down to $1,000, while other lessees pay sums ranging thence down to $25.

From the upper plane of the city of Cincinnati the canal descended formerly to the Ohio by means of 10 locks, with a fall of 111 feet, measured to low water in the river. This terminal portion, though abandoned for navigation, is nevertheless utilized for power. Much of the way it is covered from view, and in part of its course the water is divided between two separate channels. Water is used successively from one level to another, and is finally discharged into the Eggleston Avenue sewer. The power here was mainly leased from 1831 to 1834, and for periods of 99 years. The leases are considered valuable, the rentals being moderate, and are not allowed to lapse from any cause. At some of the mills there are said to be weirs of stone to govern the admission of water, but in general none are in use. There is no regulating weir at the upper fall even, and when the canal becomes drawn down too far the mills are shut off. This has sometimes to be done for a few hours, occasionally for as long as half a day. In winter more or less trouble is experienced from the clogging of the canal by ice, and, as it is claimed by the millers, from the withdrawals at points along its course to fill ice-ponds. From the statements made by several of the larger manufacturers, it is judged that for about two months in the year the supply of water at their mills is, from various causes, curtailed. The principal use of power at Cincinnati from the canal is by five flouring-mills, an elevator, a linseed-oil factory, a cotton-mill, a carriage factory, and an establishment for the manufacture

a Figures as given by Mr. John B. Gregory, chief engineer of the state, in January, 1883.

of hydraulic machinery. Messrs. Whetstone & Co. manufacture linseed oil, using for that purpose about 80,000 bushels of seed annually. Gould, Pearce, & Co. run about 15,000 cotton-spindles, making no cloth, but sundry goods which might be classed as notions—lamp-wicks, shoe-strings, and other articles.

Table of utilized power on the Ohio state canals.

Canal.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized. (a)	Total water-power utilized.	Auxiliary steam-power.
				Feet.	*H. P.*	*H. P.*
Hocking	Fairfield	Flouring and grist	1	10	25	.....
Do	Hocking	Saw	1	8	20	.....
Miami and Erie	Hamilton	Carriages and wagons	1	.....	.....	.....
Do	....do	Cotton	1	11½	60	60
Do	....do	Elevator	1	.....	.....	.....
Do	....do	Flouring and grist	6	70½	365	80
Do	....do	Gold pens	1	.....	15	15
Do	....do	Machinery	1	11	40	.....
Do	....do	Oil	1	.....	.....	.....
Do	....do	Paper	5	60	276	425
Do	Butler	Flouring and grist	9	17	219	.....
Do	....do	Paper	7	52½	683	336
Do	....do	Saw	1	5	11	.....
Do	Montgomery	Agricultural implements	2			
Do	....do	Cotton	1			
Do	....do	Flouring and grist	4			
Do	....do	Kaolin and ground earths	1	Two falls, 12 and 8 feet.	*b* 320	*b* 215
Do	....do	Linseed oil	2			
Do	....do	Machinery	2			
Do	....do	Varnish	1			
Do	....do	Woolen	2			
Do	....do	Flouring and grist	5	37	142	.....
Do	....do	Paper	1	10	80	300
Do	....do	Saw	2	7+	27	.....
Do	Miami	Flax, dressed	1	10	35	.....
Do	....do	Flouring and grist	8	68	350	.....
Do	....do	Linseed oil	1	10	25	.....
Do	....do	Woolen	1	10	40	40
Do	Shelby	Agricultural implements	1	10	10	.....
Do	....do	Saw	1	24	60	.....
Do	Auglaize	Flouring and grist	6	66	235	95
Do	....do	Saw	4	30+	90	.....
Do	....do	Vegetable oil	1	16	35	.....
Do	....do	Wooden handles	1	16	25	40
Do	....do	Woolen	2	23	47	60
Do	Allen	Flouring and grist	2	17	62	.....
Do	....do	Lumber, planed	1	8	17	.....
Do	....do	Saw	1	9	41	.....
Do	....do	Woolen	1	10½	35	.....
Do	Van Wert	....do	1	8½	15	.....
Do	....do	Paper	1	6	28	70
Do	Putnam	Flouring and grist	1	9	52	.....
Do	Paulding	....do	1	24	50	.....
Do	Defiance	....do	2	23	140	65
Do	....do	Machinery	1	14	50	30
Do	....do	Wooden packing-boxes	1	10	24	.....
Do	....do	Woolen	1	18	21	.....
Do	Henry	Flouring and grist	2	32	58	.....
Do	....do	Saw	1	18	30	.....
Do	....do	Tannery	1	18	15	.....
Do	....do	Wooden handles	1	18	15	.....
Do	Lucas	Agricultural implements	1	17	98	.....
Do	....do	Flouring and grist	5	87	800	.....
Do	....do	Paper	3	60	260	.....
Do	....do	Saw	1	16	25	.....
Ohio	Cuyahoga	Drugs and chemicals	1	6	12	10
Do	....do	Flouring and grist	1	8	47	.....
Do	Summit	... do	1	8½	14	40
Do	....do	Pumps	1	7	15	25
Do	....do	Saw	2	14	30	40
Do	....do	Tannery	1	12	20	16

a In this column the same fall is, doubtless, in some cases counted more than once, the census enumerators' returns not indicating clearly whether several mills in a township are located all upon one privilege or upon separate privileges.

b Dayton, Cooper hydraulic canal (returns incomplete).

Table of utilized power on the Ohio state canals—Continued.

Canal.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
				Feet.	*H. P.*	*H. P.*
Ohio	Summit	Tobacco-pipes	1	3	20	20
Do	Stark	Flouring and grist	2	16	55	30
Do	....do	Boats	1	13	30	.....
Do	Tuscarawas	Woolen	1	3½	15	.....
Do	....do	Flouring and grist	5	42½	268	.....
Do	Coshocton	....do	2	16	55	.....
Do	....do	Iron castings and finishings	1	9	10	.....
Do	....do	Saw	1	12	27	.....
Do	Muskingum	Woolen	1	4	20	.....
Do	....do	Flouring and grist	3	49	340	.....
Do	Fairfield	....do	3	36	66	40
Do	Franklin	....do	2	34	110	105
Do	Pickaway	....do	1	20	40	.....
Do	Ross	....do	2	22	68	40
Do	....do	Saw	1	15	16	.....
Do	Pike	Flouring and grist	4	48	101	.....
Do	Scioto	....do	2	23	75	80
Walhonding	Coshocton	....do	2	38	165	.....
Do	....do	Iron castings and finishings	1	9	4	.....
Do	....do	Woolen	1	21	45	.....

Summary of utilized power on certain

[Embracing all tributaries on the north above and including the Great Miami

	River.	WOOLEN-MILLS.			PAPER- AND WOOD-PULP MILLS.			FLOURING- AND GRIST-MILLS.		
		Number.	Total water-power utilized.	Auxiliary steam-power.	Number.	Total water-power utilized.	Auxiliary steam-power.	Number.	Total water-power utilized.	Auxiliary steam-power.
			H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*
	Ohio state canals	11	278	109	17	1,927	1,121	76	3,934	750
1	Allegheny river and tributaries	27	386	40	3	400+	.....	293	8,571	1,924
2	Monongahela river and tributaries	12	141	82	2	450	150	197	4,036	1,538
3	Beaver river and tributaries	13	160	20	1	40	12	96	3,026	1,011
4	Muskingum river and tributaries	15	248	20	.....	.....	.....	178	5,046	1,330
5	Little Kanawha river and tributaries	.....	.....	.....	.....	.....	.....	24	462	16
6	Scioto river and tributaries	7	140	30	2	105	120	80	2,193	641
7	Great Miami river and tributaries	15	221	75	20	1,950+	1,760	167	5,541	402
8	Sundry small streams	5	69	6	1	55	50	260	6,380	1,720
	Total, aside from Ohio canals	94	1,371	273	20	3,060+	2,092	1,295	35,855	8,582
	Total, including Ohio canals	105	1,649	373	46	4,387+	3,213	1,371	39,789	9,332

a Comprising steel works, machine-shops, blacksmith-shops, and works for the manufacture of agricultural implements, axes, cutlery and edge-tools, hardware;
b Comprising carpenter, wheelwright, and cooper shops, and concerns for the manufacture of beehives, carriage and wagon materials; coffins, burial-cases, and barrows.
c Comprising cotton-mills (2), knitting-mills, bakeries, flax-dressing works, marble- and stone-works, potteries, pumping works for water-supply, scouring compounds, butter and cheese.

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tributaries of the Ohio river.

river, and all tributaries on the south above and including the Little Kanawha river.]

SAW-MILLS.			METAL-WORKING ESTABLISHMENTS. (a)			WOOD-WORKING ESTABLISHMENTS. (b)			SUNDRY OTHER ESTABLISHMENTS. (c)			TOTAL.			
Number.	Total water-power utilized.	Auxiliary steam-power.	Number.	Total water-power utilized.	Auxiliary steam-power.	Number.	Total water-power utilized.	Auxiliary steam-power.	Number.	Total water-power utilized.	Auxiliary steam-power.	Number.	Total water-power utilized.	Auxiliary steam-power.	
	H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*	
16	377	40	12	275	110	6	111	40	15	316+	106	153	6,618+	2,267	
341	8,809	968	10	323	141	32	533	20	13	228	25	719	19,340+	3,118	1
66	1,052	18	.....	.....	.....	5	38	.....	5	78	.....	287	5,795	1,788	2
20	380	45	13	400	245	12	411	75	8	185	200	161	4,602	1,668	3
49	996	98	3	52	12	7	108	48	1	16	.....	253	7,066	1,508	4
3	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	27	509	16	5
27	504	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	116	3,008	791	6
46	897	12	19	435	165	14	221	158	11	224	22	202	9,489+	2,594	7
57	1,314	142	.....	.....	.....	2	24	.....	5	250	208	330	8,092	2,126	8
609	14,080	1,283	45	1,210	563	72	1,335	301	43	981	455	2,187	67,901+	13,549	
625	14,460	1,323	57	1,485	673	78	1,446	341	58	1,297+	561	2,340	64,519+	15,816	

iron nails, spikes, etc.; iron castings and finishings; pumps, rivets, steam-drills, turbines, and wire.
undertakers' goods; furniture, lead-kegs, pianos; sashes, doors, and blinds; shingles, staves; washing-machines and clothes-wringers; wooden handles, and wheel-

works, tanneries, and establishments for the manufacture of baskets, cordage and twine, cider, oil, gunpowder, high explosives, hosiery, patent medicines and

INDEX TO REPORT ON WATER-POWER OF THE OHIO RIVER BASIN.